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MONTHLY REPORT

ON THE NUCLEAR FUEL MARKET

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KEY LAKE
A MODEL OF CANADIAN DEVELOPMENT

By

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Presented to:

Deutsches Atomforum Winter Meeting

Bonn, Federal Republic of Germany
January 28, 1987

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KEY LAKE
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Dr. Runnalls, a resident of Toronto, Canada, worked for 20 years for Atomic Energy of Canada Ltd. until 1971, when he was appointed Senior Advisor, Uranium and Nuclear Energy in the Department of Energy, Mines and Resources in Ottawa. He also served for 5 years as Executive Vice President of Uranium Canada, Ltd. Since 1979, he has been associated with his alma mater, the University of Toronto, and is presently Chairman of the Centre for Nuclear Engineering. Dr. Runnalls is a member of Nuexco's International Advisory Committee.

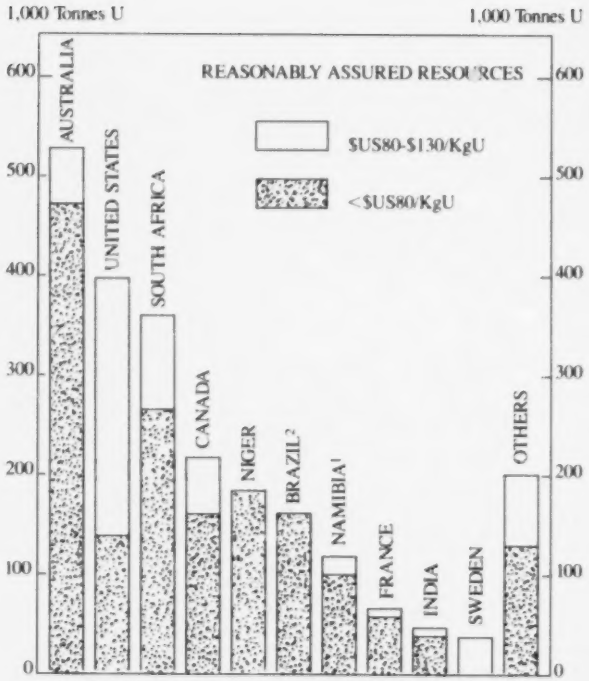
This paper was prepared and presented by Dr. Runnalls for the Deutsches Atomforum Winter Meeting at Bonn, Federal Republic of Germany, in January 1987.

Introduction

Uranium resources are widely distributed among the WOCA countries.* Recent estimates from the Nuclear Energy Agency, NEA, in Paris[1] indicate that there are 2.3 million tonnes U of Reasonably Assured Resources (see Figure 1) and 1.3 million tonnes U in the Estimated Additional Resources category. Since current requirements in WOCA countries are about 41,000 tonnes U per year, there is a comfortably large resource base to support the nuclear power industry. Coupled with this reserve there is a world-wide stock-pile of uranium which has been accumulated for at least 20 years and would provide enough fuel for existing reactors for perhaps the next three or four years [1]. The majority of the resources described above by the NEA cannot, however, be exploited at today's depressed levels of approximately $US 20/lb U_3O_8 ($52/kg U). In fact, the lowest cost category outlined in the NEA report[1] is up to $80/kg U ($31/lb U_3O_8).

The most important producing countries in order of decreasing production for 1985 were Canada, South Africa, United States, Namibia, Australia, Niger and France. Collectively, these countries accounted for 96% of WOCA uranium production in 1985. The largest production came from Canada (see Figure 2). As this figure indicates, the uranium output from Canadian mines in 1985 amounted to some 30% of the total from WOCA countries. It was subdivided as outlined in Table 1.

*WOCA, World Outside the Centrally-Planned-Economies Areas



1. OECD (NEA)/IAEA: Uranium Resources, Production and Demand, Paris, 1983, adjusted for production and estimated production.
2. In situ resources.

Figure 1. Distribution of Uranium Resources among WOCA countries[1]

From Table 1 it can be seen that 54% of the 1985 output was produced in Saskatchewan and the balance in Ontario.

The principal uranium deposits in Saskatchewan are located near the base of the Athabasca Sandstone Basin in the northern part of the province (see Figure 3). Uranium concentrations of commercial significance are usually found close to the interface of the overlying sandstone and the crystalline basement rocks beneath. Many of the deposits are unusually rich in uranium and can be recovered by open pit mining as indicated in Table 2.

Although no specific figures on reserves from Saskatchewan uranium deposits have been published recently, unofficial estimates indicate that Eagle Point is now thought to contain more than 50,000 tonnes U at a grade of about 2% U. Also, Phase II reserves at Cluff Lake have been increased about 50%. It will be apparent from Tables 1 and 2 that the Key Lake mine is one of the most important Canadian production centres. Currently it is the world's largest uranium-producing mine.

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Figure 2. Approximate Share of WOCA Uranium Production, 1985

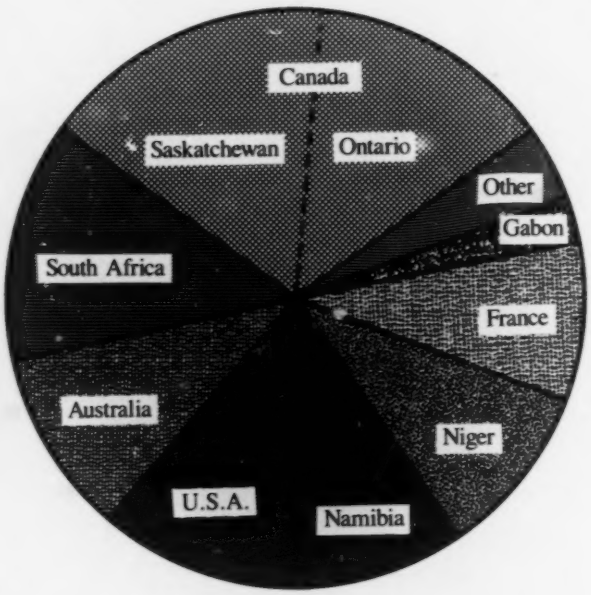

Table 1

Canadian Uranium Output, 1985[3]

Company or Mine	Location	Production, tonnes U
Key Lake Joint Venture	Saskatchewan	4,270
Cluff Mining	Saskatchewan	834
Eldorado Resources Limited (Rabbit Lake)	Saskatchewan	824
Rio Algom Limited	Ontario	
— Quirke		1,328
— Panel		827
— Stanleigh		685
Denison Mines Limited	Ontario	2,112
	Total:	10,880

Table 2
SASKATCHEWAN URANIUM DEPOSITS[5]

	Reserves, tonnes U (as of Dec. 31, 1983)	Grade, % U	Principal Mine Type
Wollaston Lake			
Rabbit Lake*	2,300	0.21	Open Pit
Collins "B"	11,500	0.38	Open Pit
Collins "D"	1,900	1.66	Open Pit
Collins "A"	6,900	9.67	Open Pit
Eagle South	6,900	0.55	Underground
Eagle Point	14,000	1.2	Underground
	43,500		
Cluff Lake			
Phase I*	400	5.9	Open Pit
Phase II	14,600	0.4	Underground/ Open Pit
	15,000		
Key Lake			
Gaertner	23,500	2.94	Open Pit
Deilmann	45,800	2.44	Open Pit
Cobble Ore	5,700	0.59	Open Pit
	75,000		

*now mined out

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Key Lake Mine

The history of the development of the Key Lake mine is worth recounting briefly because the story illustrates that even in a geologically-promising area in a stable and friendly country, the lead time between launching exploration for uranium and achieving first output can be fifteen years. This is longer than the time required to bring into operation a new nuclear power facility.

After the Rabbit Lake uranium deposit had been discovered on the eastern edge of the Athabasca Basin in late 1968, there followed a major influx of uranium explorers into northern Saskatchewan. Many of these individuals were employed by companies representing off-shore interests in nuclear power from countries where uranium resources were not present in sufficient quantities to support committed and foreseen nuclear power programs.

One such company was Uranerzbergbau GmbH (UEB), of Bonn. The Managing Director of Exploration for UEB at the time was Dr. Dieter Nottmeyer, the Chairman of today's meeting. Shortly after its founding in 1968, UEB acquired an equity in two joint ventures which were exploring along the margins of the Athabasca Basin. One of these, the North Saskatchewan Uranium Joint Venture, was headed by Inexco Mining Company (Canada) Limited with 30% equity. UEB held 10%, and the remaining equity was distributed among seven other companies[6].

Little exploratory success was achieved by the joint venture in 1969 and 1970. The growing pessimism was compounded when the Canadian government announced in March 1970 that it would take steps immediately to restrict foreign ownership in new uranium-producing mines to 33% or less[7]. Consequently, uranium exploration in Canada began to decline. The situation in Saskatchewan was no exception. By early 1971 only three companies remained in the group, each with an equity of 33.3%. They were Inexco, UEB and Bell Oil. Initially, Inexco continued as the operator of the joint venture.

New guidelines for exploration were evolved by the three companies based on knowledge obtained from the Rabbit Lake deposit in which Uranerz Canada Limited, a company affiliated with UEB, now had a 49% interest, and from information on the new uranium finds in the Northern Territory of Australia. The main criteria accepted by the joint venture group have been described by Gatzweiler et al[6] as follows:

Figure 3. Principal Uranium Deposits in Saskatchewan[4]

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1. Prospective areas had to cover the unconformity between Aphebian metasediments of the Wollaston Belt and the Athabasca formation.

2. The Aphebian metasediments had to be of shallow water deposition, including calcareous rocks.

3. The deposits searched for were fault-controlled and, more important, such faults could intersect the overlying unmetamorphosed Athabasca Sandstone. This could consequently have an effect on the erosional pattern of the sandstone margin.

Armed with these objectives, the joint venture now proceeded to work along the southeast margin of the Athabasca Basin without significant competiton.

During the summer of 1971, several radioactive swamps and two boulders rich in uranium and nickel close to the surface of the ground were found about 0.5 km northeast of Zimmer Lake and 5 km south of the Key Lake deposits yet to be discovered. Following this discovery, systematic radiometric, magnetic and electromagnetic surveys were carried out in combination with geological mapping, lake sediment and muskeg sampling. Many more radioactive boulders were discovered in the area north of Zimmer Lake in the summer of 1972. These observations prompted the initiation of a core-drilling program during the winter of 1972-73 which produced negative results.

In the meantime, an aerial photographic study had been contracted to an experienced glacial geologist. As a result, the existence of an esker was recognized, one which had ended in a delta near Zimmer Lake. This esker was typical in that it was a long, low, narrow, sinuous, steep-sided ridge composed of sand and gravel layers deposited by a stream flowing within or at the bottom of a melting glacier as it retreated[9]. Further aerial photographic studies of surficial geology revealed in November 1973 a linear-shaped depression northeast of the esker which was interpreted as a "tunnel valley". A tunnel valley is thought to have been an ice-walled channel cut in the rock below the glacier. Hence, one sees now not a ridge on the surface, but rather a depression.

These observations led to the conclusion that a uranium-nickel ore body had been intersected by the tunnel valley, had been eroded, and boulders had been deposited along the path of the esker and as far away as the delta 5 km south. The tunnel valley itself passed thorugh the contemporary sites of Karl Ernst, Dieter, and Kinikinik Lakes to the edge of Key Lake. The former two lakes were named for Karl Kegel, still with UEB, and Dieter Nottmeyer. Kinikinik Lake was named by Dr. Bayrock, a consultant for UEB, and is a native Indian expression for Bearberry. The name Key Lake was picked by Dr. B. Tan, a UEB geologist. It was chosen because the first mineralized boulders were found near Zimmer Lake (or "Room" Lake when translated from the German) and the "Key" had to be found to locate the source of such boulders[9].

The delineation of the tunnel valley and the esker made it possible to decrease considerably the target area in size. Nonetheless, it was still several kilometres long, and on the basis of geochemical anomalies, more than 1 km wide. The search was rendered more difficult because there were few outcrops in the sand-covered area. To narrow down the target zone, an intensive program was mounted consisting of a ground magnetic-induced polarization/resistivity and a vertical-loop electromagnetic survey. Promising areas were then drilled. Meanwhile, as the search intensified, UEB established a Canadian subsidiary in August, 1973 named Uranerz Exploration and Mining Limited (UEM), to represent its interests as participant in and by then operator of the joint venture. Later, in 1974, Bell Oil sold its one-third interest to the Saskatchewan Mining Development Corporation, SMDC.

Finally, on July 29, 1975, spear-headed by the efforts of UEM's geologists, the discovery hole, DDH 25, was drilled. A 7-metre length of high grade uranium and nickel ore was recovered from this hole containing an average of 7.4% U_3O_8 and 4.2% Ni at a depth of about 30 metres. The deposit was named after Dr. E. Gaertner, at that time a member of the Executive Board of Rheinbraun in the Federal Republic of Germany. Rheinbraun together with Deilmann each own 50% of UEB, the parent company of UEM.

After following the main conductive zone as mapped by the vertical and horizontal loop electromagnetic survey and by applying the same drill pattern, a second ore body was discovered in June 1976. It was named appropriately the Deilmann deposit.

During the following two years, a further 2,400 holes were drilled to fully outline the location and grade of the two ore bodies. An ore boulder field south of the Gaertner deposit containing several thousand tonnes U was delineated largely by a new drilling method called sonic drilling which allowed core recovery of the unconsolidated glacial sediments[6]. All told, some 75,000 tonnes U in unusually high-grade ore had been discovered (see Table 2).

Early in 1978, Inexco decided to sell its one-third interest in the Key Lake property. Saskatchewan Mining Development Corporation (SMDC), exercised its right to buy this interest by matching an offer of $US 158.5 million made earlier by Denison Mines Limited[10]. As a result of arrangements between SMDC and Eldorado Nuclear Limited, one-half of the Inexco interest was subsequently acquired and retained by Eldorado, leaving SMDC with a one-half interest in the venture, UEM with one-third, and Eldorado with one-sixth through a wholly-owned subsidiary, Eldor Resources Limited.

A new entity, Key Lake Mining Corporation, KLMC, was formed in 1979 as a joint operating company to develop a mine and mill on the property. Ownership in the venture remained unchanged with participation as outlined above; viz: SMDC 50%,

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UEM 33.3%, Eldor Resources 16.7%. First production was achieved in October 1983. Currently, the output rate exceeds the targeted value of 4,600 tonnes U per year.

The companies involved in the Key Lake Venture represent a diverse assembly of ownership. SMDC is a Saskatchewan provincial crown corporation, UEM is privately-owned by UEB in Bonn, Federal Republic of Germany, while Eldor Resources is a subsidiary of Eldorado Nuclear Limited, a crown corporation owned by the Candian government. Although the three partners work cooperatively together in the mining and milling operation, they are competitors in the marketing of the product from the mill. Key Lake uranium has been sold by the three companies to customers in Western Europe, Eastern Asia, and the United States.

Since first production began in 1983, ore for the Key Lake mill has been obtained from the Gaertner deposit by open pit mining. In anticipation that that deposit will have been fully utilized within a few years, development of the larger Deilmann ore body is well underway. More than 2.1 million cubic metres of overburden were stripped from the deposit by year-end 1985 in preparation for mining the ore body[11]. Profitable operations at a production level of 4,600 tonnes U per year are foreseen at this property until the late 1990's.

In summary, it is fair to say that the discovery and development of the Key Lake deposit is an example of the positive results that can be achieved by cooperation between governments in Canada, producing industries, and uranium customers abroad. The efforts involved were painstaking, time-consuming, and expensive, but they led to substantial rewards.

Other Canadian Developments

During 1985, the Eldor Mines Division of Eldorado Nuclear Limited completed a $100 million mine and mill development and expansion program[12]. An open pit mine was developed at the Collins Bay "B" zone where an estimated 12,000 tonnes U have been delineated. This ore body will provide feed averaging 0.6% uranium to the Rabbit Lake mill which Eldorado acquired from Gulf Minerals Canada Limited and Uranerz Canada Limited in 1982, and which lies 9 km to the southwest. Rabbit Lake production capacity was expected to rise to a rate exceeding 2,000 tonnes U per year in 1986. The reserves from Collins Bay "B" are sufficient to ensure production at such volumes into the 1990's [12].

At that point Eldorado will bring into production its other wholly-owned reserves from Collins Bay "A" and "D" and from Eagle Point South containing more than 40,000 tonnes U. A further deposit containing more than 20,000 tonnes U from ore averaging 2.2% U owned jointly by Eldorado, Noranda Exploration Company, and SMDC will also be available for exploitation[12]. Thus, Eldorado has discovered sufficient uranium deposits along the Collins Bay thrust and Eagle Point fault to provide a base for continuing production well into the 21st century.

In northwestern Saskatchewan, another mining operation is being conducted by Cluff Mining. Cluff is owned 80% by French-based Amok Limited and 20% by SMDC. At present the company is exploiting the "O-P" underground and "Claude" open pit mines. As the O-P deposit was depleted, production was supplemented with ore from the "Dominique-Peter" underground mine. Production from Cluff Lake in 1986 was expected to continue at about 800 tonnes U[11, 13].

In addition to northern Saskatchewan, the other principal uranium mining area in Canada is located in northern Ontario near Elliot Lake (see Figure 4).

The combined output from Rio Algom Limited's three Elliot Lake mines, Quirke, Panel and Stanleigh, is about 12,000 tonnes ore per day[14]. This mining rate is adequate to provide uranium for long term sales contracts totalling some 42,000 tonnes U which extend into the 2020's. A significant development occurred in the spring of 1986 when Rio Algom and Ontario Hydro announced that they had reached agreement on a substantial modification to their long-term contract.

The milling of Denison Mines Limited 0.1% uranium ore continues at a rate of some 8,000 tonnes per day. The uranium output from this ore augmented by a 10% contribution from in-place leaching of uranium from low grade ore underground should provide adequate material to meet Denison's contractual commitments. Such commitments amount to about 56,000 tonnes U extending to the year 2012[15].

Recent information published by Energy, Mines and Resources Canada[16] indicates that total Canadian uranium resources in the measured, indicated and inferred categories recoverable from mineable ore for up to $Cdn 300 per kg U total 545,000 tonnes U, down slightly from the 551,000 tonnes U reported for 1984.

The most significant change from 1984 to 1985 was a 19% increase in measured resources largely due to continued exploration and development in northern Saskatchewan. The level of Canadian exploration expenditure in 1985, $Cdn 32 million, was some 10% more than in the previous year. Nearly 93% of the exploration costs were expended in Saskatchewan (73.4%) and in the Northwest Territories (19.4%).

The ten operators with the largest exploration budgets in 1985 listed in alphabetical order were:

Amok Limited
CEGB Exploration Canada Limited
Cigar Lake Mining Corporation
Cogema Canada Limited
Eldor Resources Limited
Minatco Limited

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PNC Exploration (Canada) Limited
Saskatchewan Mining Development Corporation
Uranerz Exploration and Mining Limited
Urangesellschaft Canada Ltd.

These companies accounted in aggregate for about 97% of the total spent in 1985[16]. Two-thirds of the expenditures were made by companies based in countries abroad where indigenous uranium supplies are insufficient to meet existing and foreseen nuclear power programs.

Much of the surface development drilling in 1985 was carried out in conjunction with major programs in the Athabasca Basin in northern Saskatchewan. The most exciting prospect in the area is the Cigar Lake deposit near Waterbury Lake. The total ore reserve estimate for the deposit stands at 150,000 tonnes U[17]. This is subdivided between two regions — the main pod zone and the western extension. Reserves in the former mineralized area contain 110,000 tonnes U averaging 12% uranium. The western extension is estimated to contain inferred reserves of 40,000 tonnes U in ore averaging 4% uranium[17].

The Cigar Lake uranium deposit is flat, crescent-shaped in cross-section and has a thickness varying from 1-20 metres with an average thickness of about 7 metres. It is located at a depth of 430 metres at or near the contact between the overlying Athabasca sandstone and the underlying metamorphic gneisses.

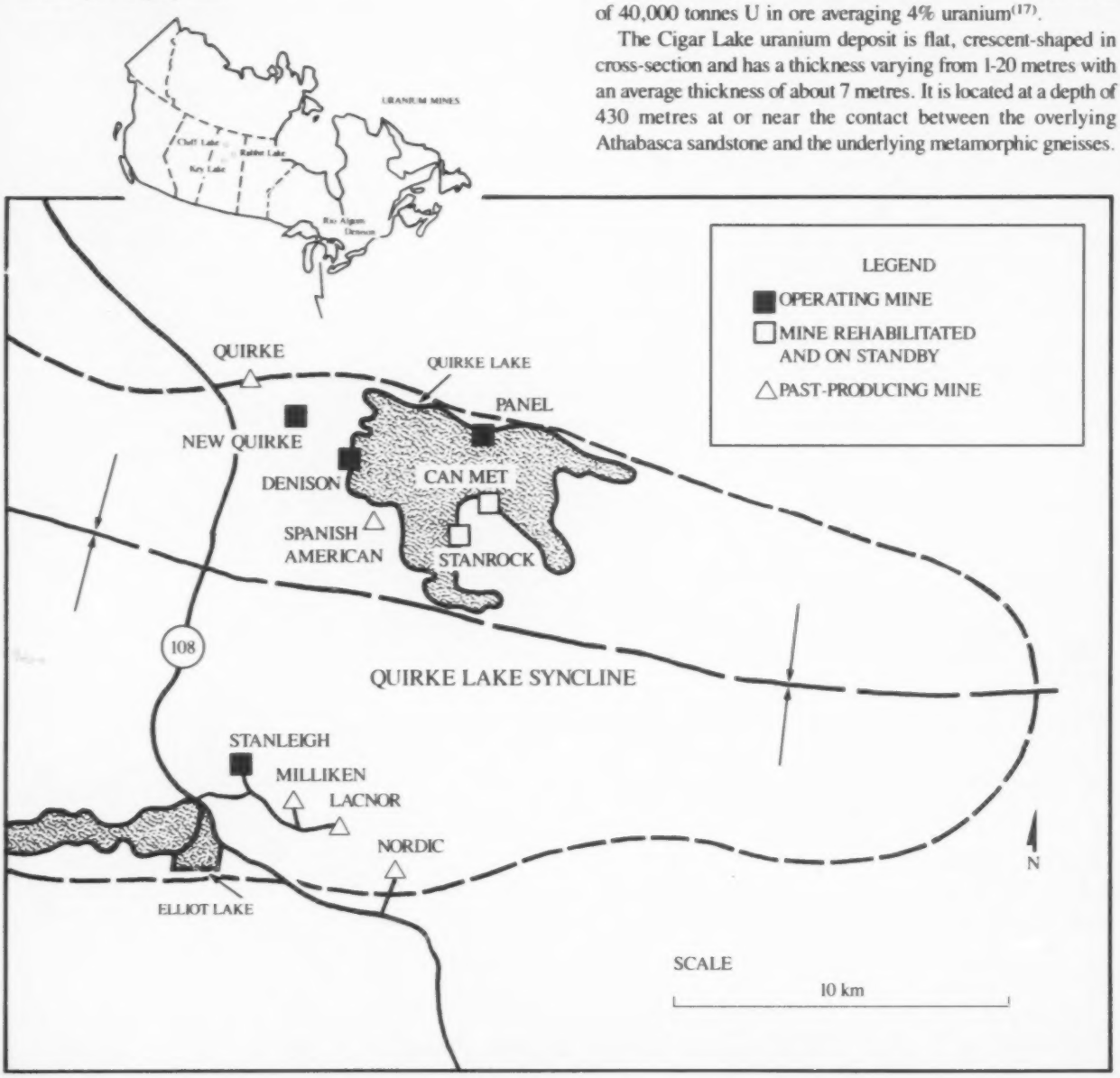

Figure 4. Elliot Lake, Ontario Producing District[4]

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The contacts of the mineralization with the barren rock above and below are very sharp, with the grade increasing from no measurable value to several percent uranium over a few centimetres. The mineralization is enclosed in a zone of intense hydrothermal alteration extending down to 100 metres into the basement rocks and upwards to 200 metres into the sandstone. Such far-reaching alteration zones may be associated with other uranium deposits in the Athabasca Basin adding a new powerful discovery aid for future exploration.

The rich nature of the Cigar Lake ore and the geological conditions pose particular mining problems. Nevertheless, several sophisticated mining techniques appear to be feasible and plans are underway to examine detailed mining methods with the expectation that production could commence at a rate of 4,600 tonnes U per year by 1993[17]. Undoubtedly, production costs will be appreciably higher than those associated with current uranium recovery operations in Saskatchewan. The development is being carried out by a newly-formed corporation, the Cigar Lake Mining Corporation, which is owned by the following group:

Saskatchewan Mining Development Corporation (50.75%)
Cogema Canada Limited (32.625%)
Idemitsu Uranium Exploration Canada Ltd. (12.875%)
Corona Grande (wholly-owned subsidiary of Cogema) (3.75%)

Here again the ownership is a mixture of domestic goverment interests and companies from consuming countries abroad.

Several other deposits with commercial potential have been discovered in the Athabasca Sandstone region and further north in the Northwest Territories. Prospects for additional development across the country are also promising since a large number of uranium deposits have already been identified.

Domestic Requirements and Export Policy

Some of Canada's uranium is required for domestic heavy-water-moderated natural-uranium-fuelled reactors of the CANDU design. Currently, nearly 10,800 MWe of nuclear generating plants have been commissioned and another 4,300 MWe are under construction as shown in Table 4.

Canada's last major nuclear commitment, the four-unit Darlington station of Ontario Hydro, should be in service by 1992. No further nuclear stations are planned at present. Hence

Table 4

COMMERCIAL NUCLEAR UNITS IN CANADA

Station/Unit	MWe net per Reactor	Type	Operating Entity	COD	Percent Complete
NPD	22	PHWR	AECL[1]	1962	100
Pickering 1, 2	515	PHWR	OH[2]	1971	100
Pickering 3	515	PHWR	OH	1972	100
Pickering 4	515	PHWR	OH	1973	100
Bruce 1, 2	754	PHWR	OH	1977	100
Bruce 3	754	PHWR	OH	1978	100
Bruce 4	754	PHWR	OH	1979	100
Point Lepreau	635	PHWR	NBRUN[3]	1983	100
Gentilly 2	638	PHWR	HYQ[4]	1983	100
Pickering 5	516	PHWR	OH	1983	100
Pickering 6, 7	516	PHWR	OH	1984	100
Bruce 6	784	PHWR	OH	1984	100
Bruce 5	784	PHWR	OH	1985	100
Pickering 8	516	PHWR	OH	1986	100
Bruce 7	784	PHWR	OH	1986	100
Total MWe in Operation	10,787				
Bruce 8	784	PHWR	OH	1987	100
Darlington 2	881	PHWR	OH	1988	81
Darlington 1	881	PHWR	OH	1989	58
Darlington 3	881	PHWR	OH	1991	24
Darlington 4	881	PHWR	OH	1992	14
TOTAL MWe	15,095				

[1]AECL: Atomic Energy of Canada Ltd.
[2]OH: Ontario Hydro.
[3]NBRUN: New Brunswick Electric Power.
[4]HYQ: Hydro Quebec.

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the current annual domestic demand of about 1,800 tonnes U will grow to some 2,100 tonnes U and will remain near that level until after the turn of the century.

During the past few years, long-term security of supply of uranium for the domestic industry has decreased in importance because growth projections for nuclear generating capacity have decreased, the uranium resource base has increased, and the domestic utilities have concluded long-term contracts with producers for future supplies. Canadian uranium production will be considerably in excess of annual domestic needs of some 2,100 tonnes U, being in the range of 11,000-12,000 tonnes U per year for at least the next decade. Thus Canada's position as a secure exporter seems assured for many years into the future.

The country's three main trading partners in terms of scheduled deliveries since 1968 and committed future deliveries continue to be the United States, East Asia and countries in Western Europe. Outstanding committed deliveries for the period 1986 through 2003 total about 63,000 tonnes U, some 12% of Canada's known resources as of December 1985 as shown in Figure 5[2]. During the time period 1986 through 1990, contracts signed to date by Canadian producers will provide about 22% of WOCA requirements, as detailed in Figures 6 and 7.

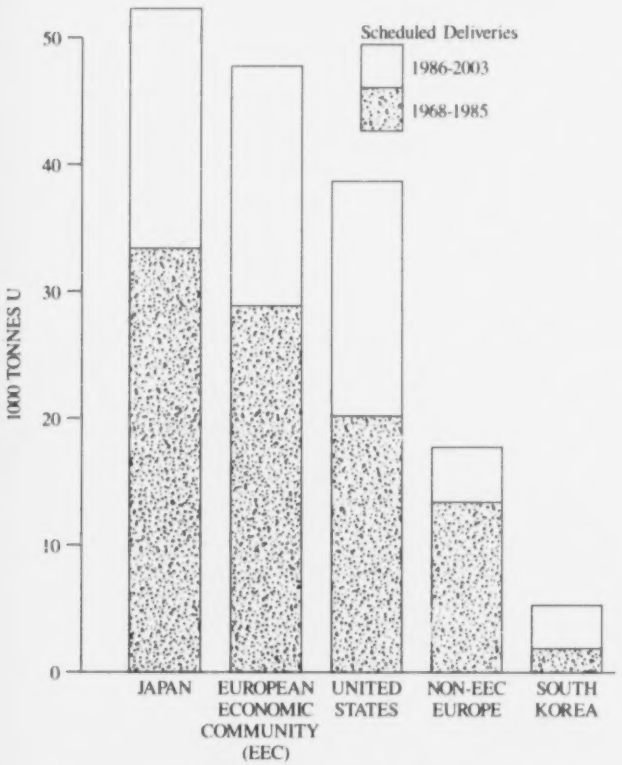

Figure 5. Scheduled Deliveries of Canadian Uranium for the Export Market[2]

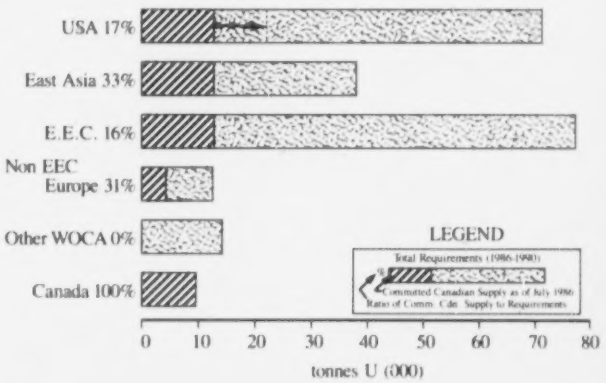

Figure 6. Uranium Requirements and Committed Canadian Supply, 1986-1990[2]

Given the firm production base, the significant number of already-found deposits yet to be developed, and the geological potential of the country, it is probable that Canada will continue to play a major role in world uranium supply for many decades into the future.

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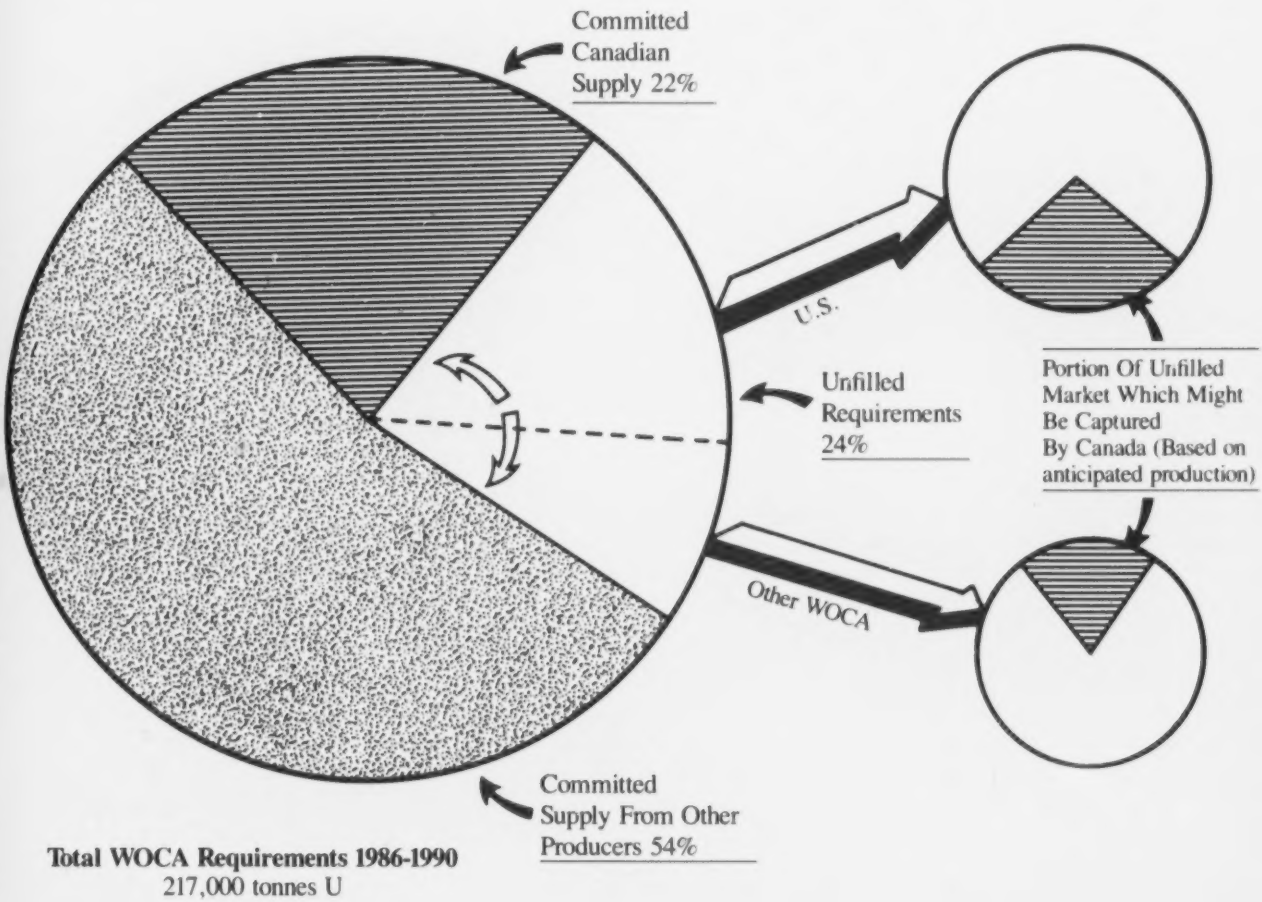

Figure 7. Canada's Share of the WOCA Uranium Market 1986-1990[2]

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EXECUTIVE SUMMARY
REPORT 222
(All data as of January 31, 1987)

Exchange Value $16.65, down 0.10

The **Exchange Value** is **$16.65** per pound U_3O_8, down $0.10 since last month.

UF_6 Value $47.75, unchanged

The **UF_6 Value** is **$47.75** per kilogram U as UF_6, unchanged since last month.

Transactions

Four recent natural uranium sales are reported, involving **100,000 to 300,000** pounds equivalent U_3O_8 in the near term, and 3,000,000 to 5,000,000 pounds equivalent U_3O_8 in the longer term. Two sales involved spot or near-term delivery, and met the conditions for inclusion in the Transaction Value. No transactions are reported involving natural UF_6.

Supply-Demand Ratio decreased to 1.8:1

Active spot and near-term **uranium supply** amounts to **3.8 million** pounds U_3O_8 equivalent, down 300 thousand pounds since last month. Active spot and near-term **uranium demand** totals **2.1 million** pounds, up 1.3 million pounds from last month. The spot and near-term **supply-demand ratio** decreased to **1.8:1.**

Transaction Value $17.35, unchanged

The **Transaction Value** is **$17.35** per pound U_3O_8, **unchanged** since last month. The calculation includes 16 transactions involving a total of 2.4 million pounds U_3O_8 and equivalent UF_6, and covers a period of 5 months.

Loan Rate declined to 3%

The **Loan Rate** is **3 percent** per annum, down one percent.

Conversion Value $1.80, unchanged

The **Conversion Value** is **$1.80** per pound U as UF_6, unchanged since last month. Active secondary market supply for conversion services for delivery within three years totals 330 thousand pounds U as UF_6. Active demand totals 250 thousand pounds U as UF_6. No secondary market conversion transactions are reported.

SWU Value for delivery within one year: $80, unchanged

The **SWU Value** at .3 tails and for delivery within one year is **$80** per SWU, unchanged since last month. No secondary market SWU transactions are reported.

* * *

Focus

India's national plans call for considerable growth in its nuclear industry in coming years. At present, India operates six commercial nuclear reactors, of which two are BWRs (GE) and four are heavy water reactors of the CANDU type. India's policy for nuclear development relies heavily on domestic supply of the entire nuclear fuel cycle and domestic manufacture of reactors.

Raw Materials

US uranium production in 1986 increased for the first time in five years, to approximately 13.8 million pounds, approximately 22 percent higher than 1985. This article examines US uranium industry activities state by state.

Canada

The government of British Columbia has announced that it will allow the existing seven-year moratorium on uranium exploration and mining to lapse in February 1987.

South Africa

Fourth-quarter uranium production from Chamber of Mines producers totaled 2,782,000 pounds U_3O_8, a decrease of 4.3 percent from the third-quarter. 1986 production totaled 11,563,000 pounds U_3O_8, declining 5.4 percent from 1985 figures.

United States

A Study Group composed of Atomic Industrial Forum (AIF) members has issued a report entitled *Standardization of Nuclear Plants in the U.S.*, which presents recommendations for regulatory changes, and shows cost advantages of standardization. In particular, the report recommends the issuance of Design Certifications, a new type of licensing procedure for nuclear plant and subsystem designs.

United Kingdom

The report of the Sizewell B public inquiry has finally been made public. Sir Frank Layfield, the Chief Inspector, has recommended that consent and planning permission for the plant be granted.

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NUEXCO REPORT 222 FIGURES OF THE MONTH (January 31, 1987)	This Month (Report 222)	Last Month (Report 221)	12 Months Ago (Report 210)
Exchange Value[1]	16.65	16.75	17.00
Transaction Value[1]	17.35	17.35	16.55
UF_6 Value[2]	47.75	47.75	47.00
Loan Rate[3]	3%	4%	5%
Conversion Value[4]	1.80	1.80	1.60
Near-Term Uranium Supply[5]	3.8	4.1	3.9
Near-Term Uranium Demand[6]	2.1	0.8	2.8
Near-Term Supply-Demand Ratio	1.8	5.2	1.4
Recent Uranium Sales:			
Number of Transactions[7]	4	1	6
Quantity of Material[8]	3.6	0.1 - 0.3	8.7
Nuexco SWU Value:[9]			
at 0.3 tails assay and delivery within one year	80	80	80
USDOE SWU Prices:			
USEC	119.00[10]	119.00[10]	125.00[11]
AFC	153.00[12]	153.00[12]	153.00[12]
Requirements	157.00[12]	157.00[12]	157.00[12]
Incentive Price	90.00[13]	90.00[13]	—
Market Value of Enriched UF_6[14,15]:			
2.5 w/o U_{235}	459	459	460
3.0 w/o U_{235}	588	588	589
3.5 w/o U_{235}	719	719	720
4.0 w/o U_{235}	852	852	854

[1]US $ per pound U_3O_8 equivalent.
[2]US $ per kilogram U as UF_6.
[3]Per annum.
[4]US $ per pound U as UF_6.
[5]Active inquiries to sell, for delivery within 12 months after contract signing (millions of pounds U_3O_8).
[6]Active inquiries to purchase, for delivery within 12 months after contract signing (millions of pounds U_3O_8).
[7]Uranium sales only; does not include loans, conversion, or SWU transactions.
[8]Millions of pounds U_3O_8, equivalent.
[9]US $ per SWU.
[10]Effective 10/1/86.
[11]Effective 10/1/85.
[12]Effective 10/1/84.
[13]Effective 10/1/86, for up to 30% of annual requirements
[14]Calculated using the Nuexco Exchange Value, Conversion Value, and 0.30 percent tails assay. From 4/30/85 to 11/30/85, calculations used the Nuexco SWU Value for DOE origin and delivery by the end of FY86. As of 12/31/85, calculations use the SWU Value for delivery within one year.
[15]US $ per KgU as UF_6, rounded to the nearest $.

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MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

February 1987 No. 222

R. WESLEY MILLER, *EDITOR* CHARLES B. LEWIS, *ASSISTANT EDITOR*

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To Our Readers

Nuexco is pleased to announce that Gerald Murdock has joined Concord-Nuexco International Corporation at its headquarters in Denver. Gerry was previously Vice President-Marketing at Kansas-Nebraska Natural Gas Company's subsidiary, Wyoming Fuel Company, where he had the responsibility for the marketing of coal and uranium. Prior to that, Gerry was Vice President-Sales for Mobil Coal Producing Inc. From 1969 to 1976 he was at General Electric where his responsibilities included the marketing of BWR s in the Far East. Gerry is a graduate of the Institute of Far Eastern Languages at Yale University where he studied Mandarin Chinese. He has a BS in Nuclear Engineering from the University of Tennessee and an MBA from the University of Denver.

Gerry's new responsibilities will include involvement in the increased Far East activities of Nuexco and Concord and the marketing of certain domestic new business opportunities.

* * *

Included in this Report is a slightly abridged version of a speech presented by Dr. O.J.C. Runnalls at the Deutsches Atomforum Winter Meeting, Bonn, Federal Republic of Germany, in January 1987. Dr. Runnalls is Chairman, Centre for Nuclear Engineering, and Professor of Energy Studies at the University of Toronto, Toronto, Canada. Dr. Runnalls is a member of Nuexco's International Advisory Committee.

* * *

Nuexco will host a hospitality suite during the Atomic Industrial Forum's Fuel Cycle Conference '87 at the Westin Hotel, Copley Place, Boston, March 15-18. We look forward to seeing you there.

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NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of January 31, 1987)

The **Exchange Value** is **$16.65** per pound U_3O_8, down $0.10 since last month. **Active supply** of natural uranium (concentrates and UF_6) for spot or near-term delivery totals **3,845,000** pounds U_3O_8 equivalent, down 300 thousand pounds since last month. The corresponding figure for **active demand** is **2,143,000** pounds, up 1,343,000 pounds. The spot and near-term **supply-demand ratio** decreased to **1.8:1.**

The *Current Market Data* section of this Report lists four natural uranium concentrate sales. The two near-term transactions totaled 100,000 to 300,000 pounds U_3O_8 equivalent; the two longer term transactions totaled 3,000,000 to 5,000,000 pounds U_3O_8 equivalent. No transaction involving UF_6 is reported. US-origin natural uranium is commanding a premium of $0.85 per pound U_3O_8 (up $0.10) in the form of concentrates, and $2.50 per kilogram U (unchanged) in the form of UF_6.

The **Transaction Value** is **$17.35** per pound U_3O_8, unchanged since last month. The calculation extends over a 5-month period and includes 16 transactions involving 2.4 million pounds equivalent U_3O_8.

The **UF_6 Value** is **$47.75** per kilogram U in UF_6, unchanged since last month. A significant price difference between what buyers are willing to pay and what sellers will accept still influences the UF_6 market.

The **Conversion Value** is **$1.80** per pound U in UF_6, unchanged since last month. Active supply of secondary market conversion services for delivery within three years totals 330 thousand pounds U as UF_6. Active demand totals 250 thousand pounds U as UF_6. No secondary market conversion transactions are reported.

The **Loan Rate** is **3 percent** per annum, down one percent.

* * *

The Exchange Value declined $0.10 this month, to $16.65 per pound U_3O_8, reflecting sellers' continued aggressive competition in response to spot and near-term sales opportunities. Substantial differences exist between prices buyers are willing to pay and those sellers are willing to accept, but sellers have been sufficiently creative and flexible in other commercial terms and conditions to make sales possible.

Amid increasing speculation that a resolution of the court case involving DOE and the US producers is imminent, the premium (relative to the Exchange Value) for US-origin concentrates has increased $0.10 since last month, to $0.85 per pound U_3O_8. Demand for Canadian-origin uranium does not appear to be especially strong; many US utilities are waiting to clarify their positions with regard to purchase of US-origin material, and European buyers generally prefer material without restrictions imposed on its end-use. An increase in demand for unrestricted uranium has made uranium of African origin more competitive in Europe; that is, it commands prices approximately on parity with other non-US material.

The large decrease in the supply/demand ratio this month was the result of a substantial increase in demand, much of which is discretionary. While such an increase in demand might be expected to cause prices to rise, competition among sellers has maintained a high level of available supply. Furthermore, discretionary buyers are highly sensitive to price and material origin, and are unwilling to raise their bid levels.

The continuing uncertainty resulting from non-resolution of the court case remains the dominant market factor, particularly in the USA. Market participants' behavior is being driven by their expectations regarding the resolution of this suit.

1. The very existence of a premium for US-origin material is a result of these expectations.

2. Market participants expect that the lawsuit will not only be resolved soon, but will be resolved in a way that is favorable to US producers.

3. Participants expect that a favorable ruling will achieve a level of import restrictions high enough to cause a direct upward movement of the price cycle.

Some buyers, due to their own special circumstances, have elected to move forward with long-term procurement, but most appear to be waiting for the court ruling before entering the market.

If the lawsuit is resolved in a way that is unfavorable to US producers (or not as favorable as expected), the premium for US-origin material may not increase as much as expected, or could even disappear. Given such a possibility, some potential buyers naturally are waiting until the lawsuit is resolved if they do not need to make purchases to fulfill current requirements. On the other hand, an Appeals Court ruling upholding Judge Carrigan's order in all respects could trigger substantial new demand for long-term supplies of US-origin uranium, resulting in upward price pressure in both the longer-term and spot markets.

* * *

The Loan Value dropped this month, to three percent. This decline reflects the general drop in interest rates. Loan transactions involving large quantities of material may potentially be concluded at lower rates than those involving smaller quantities.

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Because uranium inventories remain high, the emergence of any firm loan demand could be expected to result in supply being made available.

* * *

The Conversion Value was unchanged since last month at $1.80. Little activity was evident in the market for conversion services, and supply and demand both decreased since last month. No conversion transactions are reported.

* * *

ENRICHED URANIUM AND SWUS

The SWU Value is unchanged since last month, remaining at $80 per SWU. The SWU Value refers to SWU at a tails assay of 0.30 weight-percent U_{235} and for delivery within one year. No SWU transactions are reported in the *Current Market Data* section of the Report. Origin continues to be the prime consideration in determining prices paid for SWUs, although other factors, namely dates for delivery and notification, whether the SWU is contained in enriched product or is virgin SWU, payment terms, and quantities available exert an influence on prices. There continues to be a large spread of prices in the SWU market. Virgin or upgrade SWU continues to sell at a premium, while SWUs contained in enriched product sell at a discount.

One large SWU buyer entered the market this month. Although the entry into the market of buyers with small requirements may not tend to stimulate a response from potential sellers, demand for large quantities of SWUs could bring sellers into the market.

Nuexco has not reported any secondary market SWU transactions for the past two months. In fact, there has been some activity during that period in the market for near-term delivery of enrichment services, particularly in Europe. However, that activity has generally involved SWUs of Techsnabexport (Soviet) origin. Thus far Nuexco has refrained from reporting such activity because it involves sales by a primary SWU supplier and because the market for Soviet-origin SWUs is limited to a small fraction of the international market. However, the SWU market is showing an increasing tendency to blur the distinction between primary and secondary transactions, as traders and brokers become more active with primary suppliers.

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CURRENT MARKET DATA

January 31, 1987	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**$16.65**/lb. U_3O_8	3,845	2,143
UF_6 VALUE	**$47.75**/kgU		
CONVERSION VALUE	**$1.80**/lb. U as UF_6	330	250
SWU VALUE 0.3 tails assay; delivery within one year	**$80**/SWU		
LOAN RATE	**3%**/annum	0	0

	$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
TRANSACTION VALUE	**17.35**	2.4	16	5

[1]Supply and demand tables in *Current Market Data* section of this Report detail the numbers for each category.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Value** represents Nuexco's judgment of the price at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

   The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services.
4. The prices of conversion services or SWUs delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight-percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

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CURRENT MARKET DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (Jan 31, 1987)	Last Month (Dec 31, 1986)	12 Months Ago (Jan 31, 1986)	This Month (Jan 31, 1987)	Last Month (Dec 31, 1986)	12 Months Ago (Jan 31, 1986)
Australia (dollar)	25.16	25.21	23.74	65.41	65.55	61.71
Belgium (comm. franc)	615.98	678.06	828.06	1,601	1,763	2,153
Canada (dollar)	22.33	23.16	24.14	58.05	60.20	62.75
EEC (ecu)	14.42	15.73	18.75	37.49	40.90	48.75
Finland (markka)	74.83	80.65	90.62	194.54	209.68	235.59
France (franc)	99.28	108.00	123.82	258.12	280.77	321.90
FRG (mark)	29.75	32.58	40.38	77.35	84.70	104.98
Italy (lira)	21,213	22,681	27,577	55,149	58,966	71,642
Japan (yen)	2,535	2,677	3,275	6,590	6,961	8,514
Netherlands (guilder)	33.57	36.85	45.70	87.27	95.81	118.81
South Africa (rand)	33.98	36.81	38.72	88.34	95.71	100.67
Spain (peseta)	2,122	2,219	2,548	5,517	5,768	6,625
Sweden (krona)	107.28	114.10	127.63	278.91	296.64	331.80
Switzerland (franc)	25.02	27.22	34.29	65.03	70.76	89.14
UK (pound)	10.83	11.40	12.02	28.14	29.64	31.25
US (dollar)	16.65	16.75	17.00	43.29	43.55	44.20

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (Jan 31, 1987)	Last Month (Dec 31, 1986)	12 Months Ago (Jan 31, 1986)	This Month (Jan 31, 1987)	Last Month (Dec 31, 1986)	12 Months Ago (Jan 31, 1986)
Australia (dollar)	26.22	26.12	23.11	68.16	67.90	60.08
Belgium (comm. franc)	641.88	702.34	806.14	1,669	1,826	2,096
Canada (dollar)	23.27	23.99	23.50	60.49	62.36	61.09
EEC (ecu)	15.03	16.30	18.25	39.06	42.37	47.46
Finland (markka)	77.98	83.54	88.22	202.72	217.19	229.35
France (franc)	103.46	111.86	120.54	268.97	290.82	313.37
FRG (mark)	31.00	33.75	39.31	80.60	87.73	102.20
Italy (lira)	22,105	23,494	26,828	57,467	61,078	69,746
Japan (yen)	2,642	2,773	3,188	6,868	7,210	8,289
Netherlands (guilder)	34.98	38.17	44.49	90.94	99.24	115.66
South Africa (rand)	35.41	38.13	37.70	92.05	99.13	98.01
Spain (peseta)	2,211	2,298	2,481	5,749	5,974	6,450
Sweden (krona)	111.79	118.19	124.25	290.63	307.26	323.02
Switzerland (franc)	26.07	28.19	33.38	67.77	73.30	86.78
UK (pound)	11.28	11.81	11.70	29.33	30.71	30.42
US (dollar)	17.35	17.35	16.55	45.11	45.11	43.03

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on Jan. 30, 1987.

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CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U as UF_6			per kg. U as UF_6		
	This Month (Jan 31, 1987)	Last Month (Dec 31, 1986)	12 Months Ago (Jan 31, 1986)	This Month (Jan 31, 1987)	Last Month (Dec 31, 1986)	12 Months Ago (Jan 31, 1986)
Australia (dollar)	2.72	2.71	2.23	6.00	5.97	4.93
Belgium (comm. franc)	66.59	72.87	77.93	146.81	160.64	171.82
Canada (dollar)	2.41	2.49	2.27	5.32	5.49	5.01
EEC (ecu)	1.56	1.69	1.76	3.44	3.73	3.89
Finland (markka)	8.09	8.67	8.53	17.83	19.11	18.80
France (franc)	10.73	11.61	11.65	23.66	25.59	25.69
FRG (mark)	3.22	3.50	3.80	7.09	7.72	8.38
Italy (lira)	2,293	2,437	2,594	5,056	5,373	5,718
Japan (yen)	274.06	287.72	308.23	604.19	634.32	679.52
Netherlands (guilder)	3.63	3.96	4.30	8.00	8.73	9.48
South Africa (rand)	3.67	3.96	3.64	8.10	8.72	8.04
Spain (peseta)	229.42	238.41	239.84	505.78	525.60	528.77
Sweden (krona)	11.60	12.26	12.01	25.57	27.03	26.48
Switzerland (franc)	2.70	2.93	3.23	5.96	6.45	7.11
UK (pound)	1.17	1.23	1.13	2.58	2.70	2.49
US (dollar)	1.80	1.80	1.60	3.97	3.97	3.53

SWU VALUE AND UF_6 VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	SWU Value delivery within one year (Jan 31, 1987)	UF_6 Value per kg.U in UF_6 This Month (Jan 31, 1987)	UF_6 Value per kg.U in UF_6 Last Month (Dec 31, 1986)
Australia (dollar)	120.88	72.15	71.88
Belgium (comm. franc)	2,960	1,767	1,933
Canada (dollar)	107.28	64.03	66.01
EEC (ecu)	69.28	41.35	44.85
Finland (markka)	359.55	214.60	229.92
France (franc)	477.04	284.73	307.86
FRG (mark)	142.96	85.32	92.87
Italy (lira)	101,924	60,836	64,658
Japan (yen)	12,180	7,270	7,633
Netherlands (guilder)	161.29	96.27	105.06
South Africa (rand)	163.27	97.44	104.94
Spain (peseta)	10,196	6,086	6,325
Sweden (krona)	515.46	307.66	325.27
Switzerland (franc)	120.19	71.73	77.59
UK (pound)	52.02	31.04	32.50
US (dollar)	80.00	47.75	47.75

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on Jan. 30, 1987.

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CURRENT MARKET DATA

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Exchange or UF_6 Value	Seller	Buyer	Remarks
3934	1987	101-300	105	Producer	Utility	US origin.
3931	1988-1998	1,501-3,000	See remarks	Producer	Utility	Base price escalated. US origin.
3914	1987	50-100	100	Producer	Utility	
3913	1990-1995	301-600	R[5]	Producer	Utility	US origin.

[1]Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.
[2]If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.20 w/o tails assay.
[3]Price is not normalized to 0.20% tails assay.
[4]Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.
[5]The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

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URANIUM SUPPLY
(January 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2335	400	—	
2740	100	—	
2885B	230	—	UF_6
2893A	480	—	UF_6
2933	300	300 per year	1988-90
2967	200	—	
2973	15	—	
2975	250	—	
2989	40	—	
2990	130	—	UF_6
3023	500	500	UF_6
3121	500	—	
3127*	100	—	
3129	500	500	
3194*	100	—	
2263	—	400 per year	1988 on
2781	—	750 per year	1988-95
2981	—	600 per year	1988-91
2996	—	500 per year	1988-90
3171	—	200 per year	1988-92
TOTAL:	3,845		
INACTIVE			
2297*	100	100 per year	1988-89
2389	75	75 per year	1988-90
2764	260	—	UF_6
3128	100	—	
3166*	25	—	
3168*	50	100 per year	1988-92
2336*	—	100 per year	1988-94
2625	—	500 per year	1988 on
TOTAL:	610		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: None.

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CURRENT MARKET DATA

URANIUM DEMAND
(January 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
2878B	30	—	UF_6
2890*	350	—	
2956	350	350	U_3O_8 or UF_6
2984*	170	—	
2991	105	—	UF_6
2995*	260	—	
3009*	590	—	UF_6
3017*	230	—	
3158*	8	—	UF_6
3192*	50	—	
2738	—	1,000	1989 on
2962	—	500	1989 on
2985	—	675 per year	1992 on
3097	—	300 per year	1988 on
3147*	—	200	1989-92
TOTAL:	2,143		
INACTIVE			
2760	750	750 per year	1988-90
2798	70	—	
2936	—	400 per year	1988-95
TOTAL:	820		

*New or revised since last month.
[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 2948, 2977, 3075.

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CONVERSION SUPPLY AND DEMAND
(January 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF_6) Within 3 Years	Beyond 3 Years	Remarks
Available for Sale: ACTIVE			
3165*	330	—	
TOTAL:	330		
Available for Sale: INACTIVE			
2859*	750	750	
2988	165	—	
TOTAL:	915		
Inquiries to Purchase: ACTIVE			
2949	250	—	
TOTAL:	250		
Inquiries to Purchase: INACTIVE			
2833	400	—	
2997*	650	—	
TOTAL:	1,050		

*New or revised since last month.
[1]Measured from the date of this Report.
Projects removed since last month: None.

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CURRENT MARKET DATA

LOAN SUPPLY AND DEMAND
(January 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Within 1 Year	Beyond 1 Year	Remarks
INACTIVE			
1938	2,000	—	UF_6
2036	500	—	
2920	2,000	—	
TOTAL:	4,500		

*New or revised since last month.
[1]Measured from the date of this Report.
Projects removed since last month: 2861.

No inquiries to borrow are reported this month.

SWU SUPPLY AND DEMAND
(January 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of SWUs) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2969*	200	—	1987
3156	70	—	1987
TOTAL:	270		
INACTIVE			
2571*	55	—	1987
TOTAL:	55		
Inquiries to Purchase:			
ACTIVE			
2878	65	—	1987
2999	150	—	
3009*	200	—	
3043*	15	—	1987
TOTAL:	430		

*New or revised since last month.
[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 2879, 2985, 2987, 3015.

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CANADA

British Columbia's newly-elected Social Credit government is expected to allow the province's seven-year moratorium on uranium exploration to lapse February 28, 1987. The announcement by the Ministry of Energy, Mines and Petroleum Resources deliberately downplayed BC's uranium resources, calling them "relatively small and low in grade," possibly to lessen any potential reaction from anti-nuclear voters.

Most affected by the termination of the moratorium are the owners of the Blizzard deposit, near Kelowna in south-central British Columbia. This deposit is held by Lacana Mining Corporation with three partners: Ontario Hydro; Norcen Energy Resources Ltd. (the operator); and Campbell Resources Inc. Drilling has indicated reserves of approximately ten million pounds U_3O_8, at an average grade of 0.21 percent uranium. The deposit is considered mineable by open-pit methods. Prior to the declaration of the moratorium, owners of the Blizzard property had signed a long-term supply contract with Korea Electric Company, even though no uranium had yet been produced from the property.

Although Kelowna is a well known tourist area, with established environmental criteria for mining operations, other mines have successfuly operated in the area for many years. In particular a large, open-pit copper mine is in operation nearby, and the neighboring Highland Valley, which contains an existing copper-molybdenum mining district, is a good source of skilled labor for mining projects.

SOUTH AFRICA

Fourth-quarter uranium production from Chamber of Mines producers totaled approximately 2,782,000 pounds U_3O_8, a decrease of 4.3 percent from the third quarter figure. Table 1 shows the quarterly and total production figures from 1986.

Total production for 1986 was 11,563,000 pounds U_3O_8, a decline of 5.4 percent from the 1985 level of 12,218,000 pounds, and over twenty percent below 1984 production of 14.5 million pounds. Some of the factors which contributed to the 1986 production results include the following:

1. Buffelsfontein production declined 257,000 pounds (16.3 percent) because of mining difficulties in the Strathmore shaft area, resulting from the unexpected complexity of the geologic structure.

2. Harmony Gold Mining Company Ltd. closed its Virginia plant at the end of August 1986 because of declining uranium demand and low prices as well as the lower grade ore being mined, resulting in a production decrease of over 212,000 pounds (22.6 percent).

3. Production at Chemwes (Stilfontein) increased by 7.2

Table 1

REPUBLIC OF SOUTH AFRICA:
1986 URANIUM PRODUCTION[1]
(Thousands of Pounds U_3O_8)

Operation	First Quarter 1986	Second Quarter 1986	Third Quarter 1986	Fourth Quarter 1986	Total 1986
Buffelsfontein	353	300	362	302	1,316
Driefontein Consolidated	41	49	46	43	180
ERGO[2]	91	88	79	86	343
Harmony	231	211	171	116	728
Hartebeestfontein	238	264	267	257	1,025
JMS[3]	318	305	279	266	1,168
Randfontein	339	324	304	356	1,324
Stilfontein (Chemwes)	137	135	141	226	638
Vaal Reefs	1,082	1,069	1,107	997	4,255
Western Areas	155	147	150	133	585
TOTAL[4]	2,983	2,892	2,906	2,782	11,563

[1]Excludes Palabora Mining Company, which is not a member of the Chamber of Mines.
[2]ERGO = East Rand Gold and Uranium Company Ltd.
[3]JMS = Free State Joint Metallurgical Scheme.
[4]Columns may not add due to rounding.

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percent overall, including an increase of nearly 60 percent since the third quarter.

4. Production at Vaal Reefs and Hartebeestfontein decreased by 9.9 and 3.7 percent respectively during the fourth-quarter, but recorded slightly increased totals over 1985 figures.

Because South Africa's uranium industry is so heavily based on by-product production from gold mining, the continuation of difficult market conditions during 1986 affected uranium output less than might have been the case otherwise. Gold prices were very high in rand terms; the weakness of the rand against the dollar also accounted for record uranium prices in rand terms, because South Africa's uranium contracts are priced mainly in dollars.

UNITED KINGDOM

The long-awaited results from the Sizewell B public inquiry were released in late January. Sir Frank Layfield, the Chief Inspector who conducted the inquiry, issued a report recommending that "planning permission for a PWR power station, Sizewell B, should be granted..." Layfield based this judgment on a number of conclusions, including the following.

1. CEGB showed that building the proposed PWR is likely to save generating costs and provide a baseload station to meet future capacity needs. A new generating station will be required in the near future, and the PWR is likely to be the least-cost means of meeting the requirement.

2. Layfield determined that there is "national interest in building a PWR," and anticipated economic benefits in doing so. Achieving cost-saving electricity generation, meeting rising capacity needs, and reducing CEGB's reliance on one principal fuel all contribute to the national interest.

3. The proposed Sizewell site for the station was determined to be suitable, meeting all of the necessary technical requirements for a large generating station.

The Sizewell inquiry began in January 1982 and the Energy Secretary initiated preliminary hearings that year. Public hearings began in Suffolk in January 1983. The inquiry was intended to give the public the opportunity to discuss all of the issues surrounding nuclear power in the UK, and in particular to examine an analysis of the need, economics, safety concerns, waste management, and environmental impact of the Sizewell plant. The inquiry covered all of those areas, but it also encompassed much more as the hearings stretched far beyond the original schedule

The Central Electricity Generating Board (CEGB) assumed the responsibility of arguing the case. The arguments heard included the following.

1. Critics claimed that CEGB's overcapacity was nearly 30 percent, demonstrating little near-term need for the planned unit, and that given the prevailing schedule for the plant's completion, Sizewell would be operational several years before demand increased. CEGB on the other hand, has long argued that the considerable length of time required for construction would mean that the proposed unit would be ready just in time for a projected increase in new capacity requirements of 10,000 MWe by the year 2000, when several older plants will be approaching the end of their operating lives. Recently, in fact, CEGB needed to shed some 2,000 MW of peak electrical load by means of frequency reduction (to 49 Hz), even though it was importing power from Scotland and France at the time.

2. Advocates of nuclear power cited the advantages of reducing the nation's dependency on coal. The Sizewell unit, and the PWR program in general, could greatly advance the diversification of electricity sources.

3. While CEGB asserted that the PWR would produce electricity for consumers at lower cost than either a new AGR unit or a coal-fired plant, critics claimed that future coal costs might not be as high as predicted, and unforeseen delays and construction cost overruns could erase the PWR's cost advantage.

Over time, the inquiry evolved into a general debate over nuclear power in the United Kingdom. The considerable progress made in the implementation of the Advanced Gas-cooled Reactor (AGR) undoubtedly influenced the inquiry to some degree; six AGR units entered commercial operation between 1984 and 1985. There also was concern over the UK's lack of indigenous PWR operating experience. Although no PWRs have been built in the UK, there is no shortage of technical expertise or operating experience available from other countries, notably France and the USA. Some critics, however, questioned whether a PWR is the right choice of reactor, pointing to the development of "inherently safe" reactors, underway in Sweden and the Federal Republic of Germany. Contracts for the Sizewell unit have been given to Framatome for the reactor vessel, and to Westinghouse for design work and primary circuits. Much of the work is intended for subcontracting to suppliers in the U.K.

The expanding inquiry delayed construction on the PWR, which was originally scheduled to begin in 1982. Ironically, during the period of the inquiry delays in construction actually helped CEGB's financial situation by saving money needed to import fuel oil during the nation's 1984-85 coal miners' strike, and by deferring dollar payments on Sizewell contracts while the value of the pound sterling gained against the dollar. The public inquiry ended in February 1985, more than two years after it had begun, when final evidence was presented to the Inspector. Now that the conclusions of the Sizewell Inspector have been issued, the report will be studied by the government and debated in Parliament, so it is possible that formal approval for Sizewell

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will be granted before mid-1987. As of mid-1986, CEGB had invested heavily in the project, and is in advanced stages of design work on most of the plant.

UNITED STATES

In late 1986, the Study Group on the Practical Application of Standardized Nuclear Power Plants in the United States released a report entitled *Standardization of Nuclear Power Plants in the U.S.* The report was the product of a year-long effort by a group composed of members of the Atomic Industrial Forum (AIF), a non-profit nuclear industry membership group in the USA. The purpose of the study was to "define the actions needed for the effective implementation of standardization, and to determine the practical benefits of standardization, mainly with regard to safety, operations and cost." The report examined how plant standardization could affect the regulatory process, recommended changes, and discussed how standardization might affect the cost of nuclear power.

The Regulatory Process

On March 20, 1986 the study group sent its position paper on standardization to the Nuclear Regulatory Commission (NRC), recommending a number of proposed changes in the regulatory process. The main change involved the NRC allowing a new type of licensing procedure, called Design Certification (DC). Under the proposed procedure, once a hypothetical standardized design is granted the certification, individual licensing hearings could not challenge the validity of the approved design. Applications for the proposed DCs would require extremely detailed design information, necessitating that a nearly complete design be presented to get such a license. Upon completion of licensing, a utility should realistically be able to schedule construction around a well defined plan, thereby greatly decreasing the risk inherent in a schedule that could be interrupted for long periods by licensing or regulatory delays. In essence, using preapproved standard designs would allow one-step licensing, in contrast to the many steps now required.

A "standardized design" could be a complete nuclear plant design, a nuclear steam supply system (NSSS), the balance of plant, or any reproducible discrete subsystem that could be standardized across a variety of locations, and which could be licensed by the NRC. The owner could use those whole plant or subsystem designs to apply for construction and operating licenses. The modular nature of the process would allow greater accuracy in cost projections and reduce the uncertainties of the licensing process.

The report argued that today's nuclear licensing process is needlessly complicated. A typical plant undergoes a licensing sequence as follows:

1. Application is made for a construction permit, presenting preliminary design information.
2. NRC staff review is followed by a public hearing.
3. Plant design is finalized simultaneously as construction proceeds.
4. The utility submits its application for an operating license to the NRC.
5. The NRC technical staff reviews the application; it considers the final design and construction, equipment testing, quality control, proposed operating procedures, and changes made according to regulatory requirements enacted since the construction permit was issued. A public hearing may follow.

After the review and public hearing, design changes, more inspections and reviews, and other delays frequently occur. In the report, the study group argued that the uncertainty and instability of such a process negatively affects utilities, engineers and designers, and the public. Standardization must revolve around the security of Design Certifications, which, once approved, would not be accessible to further challenge.

The report listed several key changes that would contribute to greater acceptance of standardization and preapproval of designs.

1. The NRC should review and approve applications for standard designs even without a reference application.
2. The NRC should refrain from additional review of approved designs, unless it determines that the design fails to assure adequate levels of public health and safety, defense and security, based on new information.
3. The NRC should assign a senior manager to oversee implementation of its standardization policy.
4. The NRC should modify its regulations to ensure that once a reference application has been given approval to begin construction using a standardized design, no further changes could be required, lacking a good cause.

In addition, the study group recommended eliminating the present limitation of 10 units that applies to the number of plants that can be built under a manufacturing license, and increasing to ten years the duration of standard design approvals.

The report recommended a concept called a "reference system." This is a departure from the current licensing process, although retaining some of the existing procedures. An application for a reference design could exist independently of a construction permit or a construction and operating license, but could, if desired, follow established procedures for obtaining a Preliminary Design Approval (PDA) or Final Design Approval (FDA). Using the existing NRC procedures could help a designer by allowing NRC review at a stage when changes are more easily made, and by gaining NRC staff concurrence regarding design characteristics. PDA applications would contain a level of design information approximately equivalent to that required for current construction permit applications. The

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more complete applications for Final Design Approval would not need to be proceeded by a PDA, and could be referenced in applications for a Design Certification. The study group's position paper recommended that FDAs be made effective for 10 years, as well as allowing requests for renewals.

Design Certifications are not currently issued by the NRC. In making DCs the cornerstone of standardization, the study group recommended that DCs not *require* prior PDA or FDA applications, although they may go through that procedure if desired. DCs should be effective for ten years, renewable by the NRC for no less than five, nor longer than ten years. A highly detailed design necessarily must be part of the DC process, approximating the level necessary to obtain specific equipment in construction bids. Once a DC was issued, challenges to the design could take place only in a DC amendment proceeding. Third parties would be able to challenge the design only if significant new information indicated that the design failed to ensure adequate protection.

Effect of Standardization on Costs

The study group's analysis of costs found that significant cost savings could be expected in both direct and indirect cost categories and in time-related costs, with the greatest savings in time-related costs. The report compares a "Best Cost Experience Plant" to a model plant built using standardized designs, both using a 1,200 MWe plant model authorized in 1986. The best cost experience plant is based on the Energy Economic Data Base and uses actual cost experience. Against this model, the analysis compares a hypothetical plant built as one in a standardized series (called an n^{th} plant), which is partly determined from data available from standardized nuclear construction programs in other countries. In both models, the major cost components are analyzed in detail. The construction periods expected under the best-cost plant and the standardized plant model are eleven and six years, respectively.

Direct and indirect costs mainly covered such items as equipment and material, construction costs, design and management services, and owner's costs. According to the study, the standardized plant model showed overall cost savings of between 24 and 38 percent in the direct and indirect costs category. The most significant savings would be achieved in design and management services, which could be reduced by 66 to 72 percent compared to the best-cost model plant. These savings would be gained through sharing costs and utilizing the same reference designs among multiple facilities. The study showed construction cost reductions of between 10 and 20 percent; equipment and material cost savings of 5 to 10 percent; and savings in training manuals and technical operation specifications and procedures of 3 to 5 percent.

Cost savings that might be achieved by standardization were even more significant in the category of time-related costs, in particular escalation and financing. The projected shortening of the construction schedule, from eleven years under the best-cost model to six years under the standardized model, mainly accounted for the potential savings of approximately 75 percent. According to the data base used in the best-cost model, 61 percent of the capital costs of an average light-water reactor entering commercial operation between 1985-88 were time-related; a potential savings of 82 percent in costs of escalation and financing could be realized using the standardized plant model. In terms of overall cost savings, a standardized nuclear plant authorized in 1986 and scheduled for commercial operation in 1992 potentially could be built for 55 percent less than a model "best cost experience" plant. Such a standardized plant could be built for $1,186 per kilowatt, versus $2,650 for the best-cost model plant.

UNITED STATES

The future of the Atomic Vapor Laser Isotope Separation (AVLIS) program, the Department of Energy's laser enrichment research effort based at the Lawrence Livermore National Laboratory (LLNL), appears to be rather uncertain at this time. The Reagan administration's proposed FY 1988 budget request to Congress contains no funds to continue the program, although there is much doubt about whether the program will actually cease. The possibility exists that Congress could reinstate funding for the program, even without a specific budget request. In other to achieve zero spending by 1988, DOE must close the program during 1987, therefore it has requested that its FY 1987 budget be revised to terminate the AVLIS program.

The administration's June 1985 decision to stop development of the Gas Centrifuge Enrichment Program depended to some extent on continued progress of the AVLIS program; therefore the recent action raises questions about the direction of the DOE enrichment enterprise. The decision to cut funding could be a signal by the administration that it intends to proceed with privatization of the enrichment business as quickly as possible, or even that, while appearing to cut costs, it expects Congress to reinstate the program's budget. There is precedent for such action by Congress; when the administration cuts AVLIS funding in its FY 1987 budget request, Congress added $30 million to the program to raise the budget back to the $80 million level thought by Congress to be adequate.

The logic behind the action seems to be that elimination of costs incurred by the AVLIS program will make DOE more competitive in the short-term; disadvantages in long-term outlook would, under the assumption of some degree of privatization, largely be inherited by private industry. There remains the question of whether Congress will permit the administration and

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DOE to take a short-sighted view of the USA's future participation in the international enrichment business. The investment in development of AVLIS has given the USA a significant lead in this technology, a lead that will be surrendered to the French, whose research and development in laser enrichment technology is reportedly not far behind, if the program is terminated.

The decision to drop the AVLIS program from the proposed budget is closely tied to the issue of future privatization of enrichment services in the USA. Up to now, the government has made no firm commitment either to allow or not allow enrichment on a private basis. Potential investors are, therefore, justifiably wary of committing themselves to further research and development of the AVLIS technology, particularly as DOE already conducts similar research under the Strategic Defense Initiative (SDI), also at Lawrence Livermore National Laboratory. Lacking an unequivocal position by the Congress and the Reagan administration on privatization, it seems likely that Congress will fund continued AVLIS development.

* * *

CORRECTIONS

Last month's Report (#221, January 1987) contained the following errors.

On page one, the Report stated "conversion supply has declined and supply has increased." This should have read "conversion supply has declined and *demand* has increased."

Also, the headings for the tables on pages 25 and 26 were reversed. *US Uranium Marketing Statistics* should have identified the table on page 26, while *Volume and Price of Uranium Deliveries to the European Community* should have identified the table on page 25. We regret any inconvenience this may have caused our readers.

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FOCUS

INDIA'S NUCLEAR INDUSTRY

Introduction

India operates six commercial reactors, having a combined capacity of 1330 MWe, and is in the process of making sizeable increases in its nuclear industry infrastructure. Total capacity under development is approximately 1900 MWe; four 235-MWe reactors are under construction, and another four are in the planning stage. Government plans call for building an additional 7,000 MWe before the end of the century, for a total of approximately 10,000 MWe, which will require more than tripling the existing and planned nuclear generating base. The achieved result will likely fall far short of the plans. In addition, India also is proceeding on fast breeder development, and recently inaugurated a 40-MW(thermal) test breeder reactor. Engineering plans for a 500-MWe prototype commercial breeder reactor are also underway. Overall, India's program is self-contained and well integrated and the country has planned extensive development of commercial nuclear power, as shown in Figure 1.

India's strategy relies on indigenous development of all aspects of the nuclear power program to the maximum possible degree. Independence in the fuel cycle, and the associated freedom from international controls and restraints, has led to a reactor program based on Pressurized Heavy Water Reactors (PHWRs), which are closely linked by design to India's two original CANDU reactors, still operating at the Rajasthan complex. The Nuclear Fuel Complex (NFC) at Hyderabad has complete fuel fabrication capability, and domestic reprocessing of spent fuel takes place at several locations. Although India can produce enough natural uranium and fabricated fuel to operate its four existing PHWRs without any need to buy fuel abroad, little surplus production capacity is thought to exist, and recent uranium discoveries have not uncovered large new reserves. Considerable expansion of the reactor program, could, in the future, result in India becoming a buyer of uranium on the world market.

Background

Since the mid-1970s, India's nuclear program has operated largely independently of the rest of the world's nuclear commerce. In 1963, India and the USA signed a nuclear cooperation agreement, in which the USA promised to provide enriched uranium fuel for US nuclear reactors then being considered by India. The 30-year agreement expires in 1993. Following the signing of the agreement, India ordered two General Electric (GE) BWRs that were built at Tarapur, north of Bombay, and placed in operation in 1969.

In 1968 India refused to sign the Nuclear Non-Proliferation Treaty, claiming it is discriminatory in that its restrictions are applied unequally. However, the 1974 explosion of what India termed a "peaceful" nuclear device strongly affected India's international political relations and its commercial nuclear power program. Prior to the bomb test, Atomic Energy of Canada Ltd. (AECL) had been heavily involved in the Indian nuclear program, in design and construction of both research and power reactors. India had selected the CANDU technology for its third and fourth reactors (Rajasthan Units 1 and 2) in part because the natural uranium fuel used by the PHWRs would not require enrichment by outside parties, but also because the fuel could be supplied largely from domestic sources, and therefore would not be subject to restrictions on its disposition after use in the reactor. Following the bomb test, however, the Canadians stopped all assistance, canceling the supply of equipment for the Rajasthan units and essentially terminating nuclear cooperation with India. Under totally Indian guidance, the Rajasthan units were eventually completed, although after considerable delays.

In 1977, the US Government announced its dissatisfaction with the 1963 bilateral cooperation agreement, a situation aggravated by India's refusal to accept full-scope IAEA safeguards over its nuclear plants. The USA stated that it would consider ending its commitment to supply Tarapur with enriched uranium through 1993. In 1978, the US Congress passed the Nuclear Non-Proliferation Act (NNPA), tying US exports of nuclear fuel and equipment to the conclusion of new bilateral safeguards agreements, in particular covering the use of spent fuel. In lieu of safeguards, the USA and India were not able to agree on rights to fuel deliveries specified under the 1963 pact. The US continued to seek a conditional termination of the 1963 cooperation agreement, but one that allowed it to keep control over reprocessing of any spent fuel coming from the Tarapur plants, and providing for inspection of plants and fuel even after the agreement's end date. Conversely, India considered the portion of the fuel supplied indigenously not to be covered by any safeguards agreement, and refused to accede to the US demand that Tarapur be kept open for inspection even beyond 1993.

Finally, President Carter approved a last delivery of US enriched uranium fuel to be made to Tarapur in the fall of 1980. Between 1981 and mid-1983, while the fuel dispute continued to be unresolved and political relations between India and the USA showed considerable strain, the Tarapur units were forced to operate at less than half of capacity. By late 1982, a partial solution was agreed upon, in which France would assume US obligations to provide India with fuel, totalling approximately 20,000 KgU as UF_6 enriched to approximately 2.7 percent U_{235}. The issue of inspections and safeguards between the USA and India was left unresolved. The first French delivery was made in May 1983.

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During this period, US exports of spare parts to the Tarapur plant also became a controversial issue as the US Congress viewed such export sales as a violation of the NNPA. Considering India's nuclear test and its refusal to allow indefinite inspections of Tarapur, the NRC denied export licenses for plant equipment to GE and several subcontractors. Some members of Congress argued that Tarapur had supplied at least some of the plutonium for the nuclear explosion, and could do so again in the future, therefore concluding that exporting spare parts aided India's possible nuclear weapons development program. Eventually, most of the required spare parts were either procured from European suppliers or fabricated in India.

The issue of reprocessing rights and safeguards has not subsided. Most of India's nuclear program is not covered by any international safeguards arrangement, having been built and fueled to a large extent indigenously. India steadfastly maintains that all of its plutonium resources are and will be used for peaceful projects, such as the fueling of the fast breeder reactors planned for the next century. In developmental terms, India's disinclination to abide by international safeguards conventions drastically limits its access to nuclear technology from a number of countries, including the USSR.

India's Nuclear Power Strategy

For the last few years, the official target for nuclear power production has been the installation of 10,000 MWe capacity by the year 2000, up from the 1986 figure of approximately 1,300 MWe (see Table 2). Nearly all of this nuclear expansion is expected to be of Indian design and manufacture, and the complete fuel cycle, except for part of the low-enriched fuel for Tarapur, will also be indigenous. Probably less than ten percent of plant equipment will be purchased abroad.

Since the 1950s India has advocated, and has partially implemented a three-stage approach to nuclear technology. The first stage envisions construction of approximately 8,000 to 10,000 MWe of nuclear generating capacity using Pressurized Heavy Water Reactors (PHWRs), which use natural uranium fuel. The operating units at Madras (MAPS) and Rajasthan (RAPS), and the plants under construction or planned at Narora, Kakrapar, Kaiga, and Rajasthan are all of this type, having capacities of

Table 2

NUCLEAR POWER UNITS IN INDIA

Unit	Type	MWe	Percent Complete[1]	COD[2]
In Commercial Operation				
Tarapur (TAPS) 1	BWR	210	100	1969
Tarapur (TAPS) 2	BWR	210	100	1969
Rajasthan (RAPS) 1	PHWR	220	100	1973
Rajasthan (RAPS) 2	PHWR	220	100	1981
Madras (MAPS) 1	PHWR	235	100	1984
Madras (MAPS) 2	PHWR	235	100	1985
Total MWe in Operation		1,330		
Under Construction				
FBTR[3]	FBR	15	—	1987
Narora (NAPP) 1	PHWR	235	85	1988
Narora (NAPP) 2	PHWR	235	80	1989
Kakrapar (KAPP) 1	PHWR	235	22	1991
Kakrapar (KAPP) 2	PHWR	235	17	1992
Planned				
Kaiga 1	PHWR	235	—	1994
Kaiga 2	PHWR	235	—	1995
Rajasthan 3 and 4	PHWR	235	—	late 1990s
TOTAL MWe		3,222		

[1] According to published sources.

[2] COD = Actual or expected Commercial Operation Date.

[3] Fast Breeder Test Reactor. Unit being modified for electricity generation.

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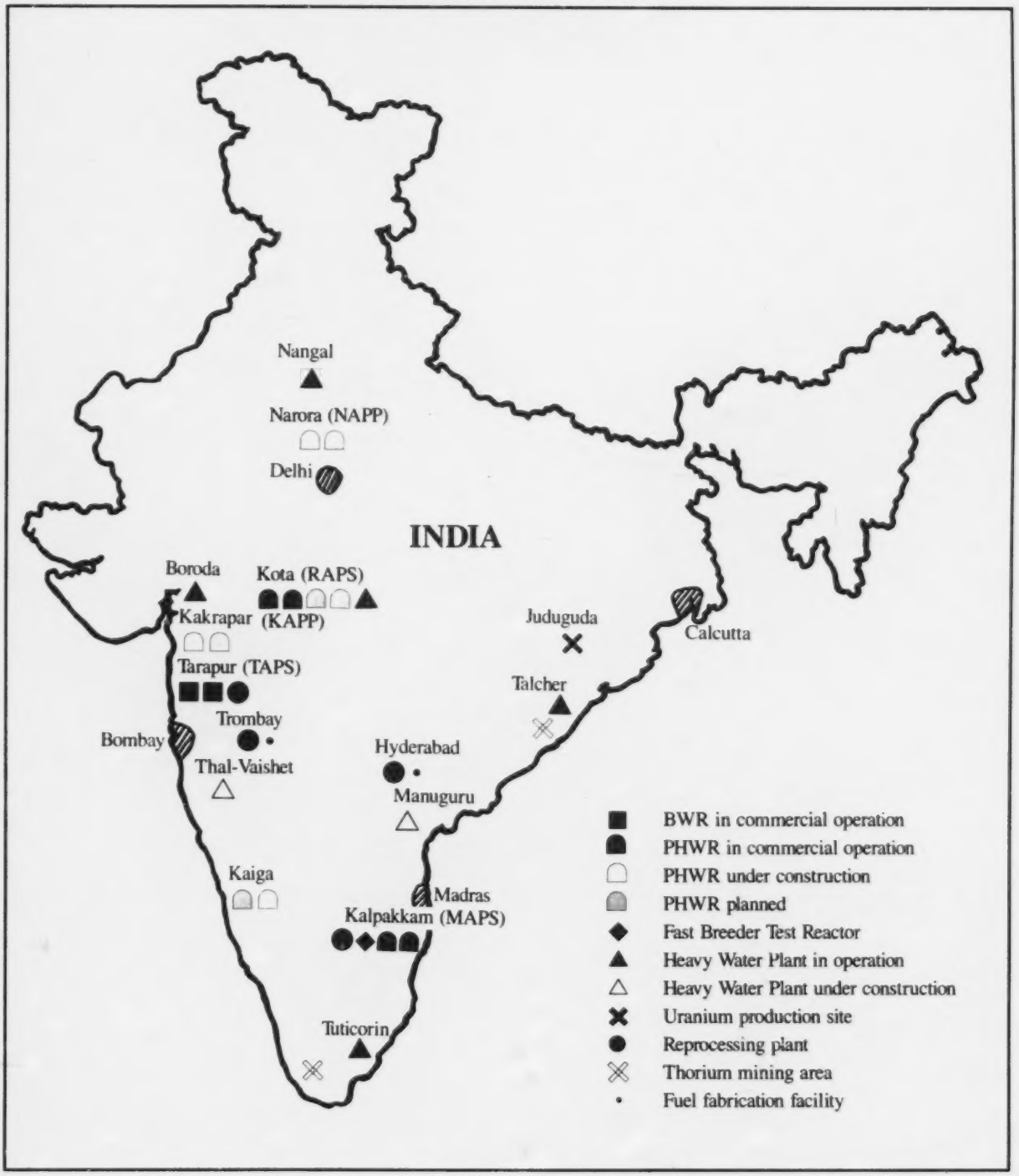
Figure 1

DISTRIBUTION OF NUCLEAR UNITS AND URANIUM PRODUCTION AREAS IN INDIA



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approximately 200 MWe. The design of a 500-MWe upgraded version of the CANDU-type reactor has been under development for some time, and a number of these paired units are expected to fulfill the first-stage plan.

In the second stage, a generation of fast-breeder reactors will be fueled by plutonium derived from the first-generation reactors. Trial operation of the 40 MWt (15 MWe) Fast Breeder Test Reactor (FBTR) at the Kalpakkam complex near Madras is the first step in India's breeder program. The next step is construction of a 500-MWe Prototype Fast Breeder Reactor. Part of the test breeder experimental program includes the irradiation of a thorium blanket, the results of which will provide information about the feasibility of a thorium-U_{233} fuel cycle.

The third stage, not clearly defined to date, could involve a generation of breeder reactors based on a uranium-thorium fuel cycle. In all these developments, national self-sufficiency is an overriding goal.

India's Reactor Program

India currently has six commercial reactors in operation, with four others under construction, as shown in Table 2. Four additional units are in the preliminary stages of development. Of the six operating units, two are BWRs (396 MWe total capacity) and four are PHWRs (884 MWe total capacity). Slightly over two percent of India's electrical generation is provided by nuclear plants.

Tarapur Atomic Power Station (TAPS — note: operating facilities are called Atomic Power Stations, such as TAPS, whereas facilities under construction are called Atomic Power Projects) — The oldest commercial reactors in India, and the only ones built on a turnkey basis by non-Indian contractors, are the twin 210-MWe BWRs at Tarapur, located about 100 km north of Bombay in the state of Maharashtra. These units were built by General Electric Corporation (GE) of the USA in the late 1960s and are some of the oldest BWRs still operating. Units 1 and 2 entered service in November 1969. Participation by Indian contractors totaled approximately 30 percent of the cost of these units. By October 1985, TAPS Units 1 and 2 had passed 100,000 hours of power generation. In 1985, Unit 1 and 2 achieved availablity factors of 71 percent and 92 percent, and capacity factors of 62 percent and 84 percent, respectively.

Rajasthan Atomic Power Station (RAPS) — Located at Kota in the state of Rajasthan, the RAPS complex contains twin 220-MWe PHWRs of the CANDU type, designed by AECL. The first unit was commissioned in December 1973, using about 45 percent imported equipment. RAPS Unit 1 has experienced problems with cracks in the reactor vessel end shield, and essentially has been shut down since September 1981. The reactor was restarted in February 1985 after repairs were made, but the unit was shut down three months later when new cracks were discovered. Given the extreme difficulty of the repairs, permanent decommissioning of the reactor is a possibility. RAPS Unit 2 entered commercial service in 1981, and has operated at a capacity factor of 57 percent and an availability factor of 71 percent during 1985. The unit reached its rated power of 200 MWe in November 1985, and was built with about 70 percent Indian participation.

Madras Atomic Power Station (MAPS) — The nuclear complex at Kalpakkam, about 75 km south of Madras, contains twin units similar to those at Rajasthan, but slightly larger (235 MWe). The design and construction is almost completely domestic, and is primarily based on experience gained from the RAPS reactors. Non-Indian equipment used in the MAPS reactors is less than fifteen percent of the total, consisting primarily of instrumentation and some stainless steel components for the fuel subassemblies. The cost of MAPS Unit 1 is reportedly about US $130 million. Unit 1 entered commercial operation in January 1984, seven years after the originally planned operating date. Unit 2 achieved criticality in August 1985, and entered commercial operation in November 1985, reportedly at a cost of approximately $190 million. MAPS Unit 1 achieved a 46 percent capacity factor and a 55 percent availability factor during 1985.

The Construction Program — The Department of Atomic Energy (DAE) currently has several reactors under construction or in the advanced planning stage. In western Uttar Pradesh, near Delhi, the Narora complex has two 235-MWe PHWRs nearing completion. Under construction for the last six years, these units are scheduled for commissioning in late 1988 or early 1989, and cost estimates for both of the units total approximately US $400 million. Foreign components in the Narora project are reported to be approximately ten percent of the total. Using a design virtually identical to the reactors at Narora, the twin PHWRs at the Kakrapar Atomic Power Project (KAPP), located about 300 km north of Bombay in the state of Gujarat, are scheduled for completion by 1992. In addition, preliminary site work is advancing at Kaiga, in the southern state of Karnataka, where similar twin units are planned. The existing Rajasthan complex also is scheduled to receive two additional 235-MWe PHWRs to complement the two units already there. Reactor sites are now planned to eventually accommodate four reactors. Assuming the master plan is followed, most of India's reactor capacity through the early 2000s will come from the sites already in use or planned.

Research Reactors — India's primary nuclear research facility, the Bhabha Atomic Research Centre (BARC), operates several research reactors at its facility at Trombay, near Bombay. The largest and newest research reactor is called DHRUVA, a 100-MWt heavy-water moderated and cooled thermal neutron

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reactor, which became operational in August 1985. Almost immediately after startup, however, DHRUVA was shut down due to severe flow-induced vibration in the fuel bundles. Operation resumed in late September 1986, but vibration problems reportedly still hinder operation. DHRUVA is one of the largest research reactors in the world, and since it was designed and built entirely in India, is not covered under any sort of safeguards arrangement. Critics claim that the unit has plutonium production capability.

There are several other research reactors located at the BARC facility. The Apsara reactor, a 1-MWt pool-type reactor built in 1956, is scheduled to be decommissioned in the near future. The Cirus 40-MWt heavy water moderated research reactor, supplied by Canada, has been in operation since 1960. The main function of Cirus has been to generate plutonium oxide fuels, test thorium oxides for fuel potential, and produce radioisotopes. Reprocessed spent fuel from Cirus fuels the Fast Breeder Test Reactor (FBTR). Purnima II, a small research reactor using U_{233} for fuel and designed for experiments in the U_{233}-Thorium fuel cycle, recently achieved criticality. Also, at the Kalpakkam facility, a 30-KW neutron source reactor is under construction.

The Fast Breeder Reactor Program — At Kalpakkam, near Madras in the southern state of Tamil Nadu, the Indira Ghandi Centre for Atomic Research (IGCAR — formerly the Reactor Research Centre) is dedicated to the development of liquid-metal fast breeder reactor technology. One of the Centre's projects, the FBTR, achieved criticality in December 1985. The FBTR, a 40-MWt reactor based on France's Rapsodie breeder, operated successfully through its first test phase, after which it was shut down for addition of steam generators, leak detection systems, and other facilities that will enable it to produce about 15 MWe of electricity. If construction proceeds on schedule, this unit should reach rated power by 1988, at a reported cost of about $54 million. Plutonium for the first core came from the Cirus research reactor, and plutonium for reload cores will be provided by reprocessed fuel from MAPS.

The FBTR, cooled by 150 tonnes of liquid sodium, uses a domestically designed mixed plutonium-uranium carbide fuel, rather than the more common mixed oxide fuel. The initial core of 22 fuel subassemblies contains 70 percent plutonium carbide and 30 percent natural uranium carbide, a fuel mix developed and manufactured at the BARC complex. According to the Department of Atomic Energy (DAE), the carbide fuel has up to 30 percent higher heavy atom density, enabling better breeding ratios; 5 to 7 times higher thermal conductivity, which allows more heat to be extracted from a reactor column; and the carbide fuel mix is more compatible with the sodium coolant compared to mixed oxide fuels.

The test breeder's four steam generators are designed to produce superheated steam at a temperature of 480 degrees C, enabling a thermal output of 40-50 MW. In general, the FBTR exhibits a high degree of fuel burnup. Design and manufacturing expertise have been provided through technical collaboration with French industry and the French Atomic Energy Commission.

Engineering plans are underway for the 500-MWe Prototype Fast Breeder Reactor (PFBR), expected to be built before the end of the century. This unit reportedly is based on technology from France's Phenix program, and will be a "pool" type design, rather than the "loop" design of the FBTR. Using the pool design, the reactor's four primary pumps and eight intermediate heat exchangers will be located inside the reactor vessel. Manufacture of all large mechanical components is expected to take place in India, including the reactor vessel, which will be 15 m in diameter, and 13 m in height.

Nuclear Fuel Resources

Exploration, mining, and milling of uranium and thorium takes place under the auspices of the DAE. One of the first institutions started under the DAE was the Atomic Minerals Division (AMD), which operates regional centres for exploration and research. The state-owned Uranium Corporation of India Limited (UCIL) and India Rare Earths Limited (IREL) conduct production operations.

India's known reserves of uranium are not particularly large, estimated by OECD/IAEA as of mid-1985 to total 62,700 tonnes U. Of these, about 35,100 tonnes are in the under $80/kg category, about 11,000 tonnes are in the $80-130/kg category, and 17,000 tonnes are classified as Estimated Additional Resources (EAR). The major focus of uranium exploration and development has been in the Singhbhum thrust belt, west of Calcutta in the state of Bihar. Within the Singhbhum district, UCIL operates India's only commercial uranium mining facility, an underground mine and mill at Juduguda, in production since the 1960s. Output from this mine and mill is estimated to be approximately 200,000 pounds U_3O_8 per year. Mill capacity is 1,000 tonnes/day of ore, although recently a major expansion of the Juduguda mine and mill has been underway, and a new 3,000 tonne capacity ore-processing plant is being added to the existing facilities. UCIL is also working to expand production in the Singhbhum area by opening new mines at Bhatin and Turamidih. Currently, small plants at Rakha and Mosaboni also contribute to UCIL's uranium operations, operating in conjunction with the copper concentrators at copper mines of Hindustan Copper Limited. At present, one of the main objectives of India's uranium industry is to improve recovery from copper tailings.

In contrast to uranium reserves, India's reserves of thorium are estimated at over 360,000 tonnes Th. At present, commercial exploitation of these thorium deposits is under the direction

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of India Rare Earths Limited (IREL), a government company in operation since 1950, and is almost entirely based on mining of placer beach sands. Mineral sands separation plants operate at Manavalakurichi and Chavara, in the southern state of Kerala, and a thorium processing plant is located at Alleppey, also in Kerala.

The large mining complex in the state of Orissa, the Orissa Sands Complex (OSC), south and west of Calcutta, is undergoing a second expansion phase. OSC mines about three million tons of sands per year, and, among other important minerals such as ilmenite, rutile and zircon, they produce about 4,000 tonnes per year of monazite, a mineral containing thorium nitrate. Recoverable reserves of monazite from placer sands in India have been estimated at 146 million tonnes.

The Rare Earths Survey Unit, responsible for exploration and mineralogical surveying under the AMD, has been actively exploring for radioactive minerals in recent years. From mid-1985 to mid-1986, over 51,000 meters of exploratory drilling were completed, the major part of which has been in the Singhbhum thrust belt of Bihar. Within the last several years, several promising deposits have been discovered, but in general, these offer only a few thousand tonnes of uranium potential at any one deposit.

Fuel Fabrication and Reprocessing

The Nuclear Fuel Complex (NFC) at Hyderabad is the main fuel fabrication unit in India, although some nuclear fuel also is produced at BARC. The complex produces natural UO_2 fuel bundles for the RAPS and MAPS reactors, as well as enriched uranium fuel assemblies for the Tarapur BWRs. The facility also produces the core axial subassemblies and thorium blanket subassemblies for the FBTR. As part of its comprehensive fuel production capability, the NFC also manufactures zircaloy and zirconium-niobium alloys for fuel element cladding.

Recent NFC expansion plans include doubling uranium oxide fuel capacity to around 180 tonnes per year, and increasing capacity for complete fuel assemblies to about 50 tonnes per year. Originally designed to produce 100 tonnes per year of PHWR fuel and 35 tonnes of finished zircaloy products, the expansion will enable the NFC to produce over 200 tonnes of PHWR fuel and 50 tonnes of zircaloy products. PHWR fuel is made from magnesium diuranate, which is then converted into UO_2, while BWR fuel is fabricated from imported UF_6.

Reprocessing of spent fuel takes place at several DAE facilities. India's first reprocessing plant was built at the BARC complex in Trombay, and was commissioned in 1964 with a capacity of about 30 tonnes per year. The Indian-designed and built plant uses the Purex process with solvent extraction columns. Fuel reprocessed at BARC comes mainly from the Cirus reactor, located on site.

The primary reprocessing plant at present (called PREFRE) is located at the Tarapur reactor site, where since 1982 spent fuel from the Tarapur reactor has been reprocessed. This facility has a rated capacity of 100 tonnes per year. In 1986, the Tarapur plant also reprocessed spent fuel from the MAPS Unit 1 reactor, and the plutonium was destined for use in the FBTR. This plant operates under international safeguards only when reprocessing safeguarded material, such as enriched UF_6 imported from France. When reprocessing domestic fuel material, no safeguards apply to its operation.

At the reactor complex at Kalpakkam, the site of the MAPS and FBTR units, DAE is building a plant for reprocessing spent zircaloy-clad UO_2 fuel from MAPS, having an estimated capacity of 100 tonnes per year. The production line also is designed to accept mixed carbide, and possibly nitride, spent fuels from the breeder reactor program. Also at Kalpakkam, a fuel reprocessing development laboratory has been set up as part of the IGCAR facility.

Heavy Water Production

India's PHWR reactor program depends to a great extent on an adequate supply of heavy water — deuterium (D_2O) — and is committed to domestic supply. Indian nuclear authorities admit that loss of heavy water is one of the recurring problems encountered in running the existing PHWRs, which use the product both as moderator and as coolant. At present, while India's production of heavy water is close to meeting its requirements, some is regularly imported from the Soviet Union. In order to meet requirements for the series of reactors under construction and planned for the immediate future, an expansion and upgrading program of heavy water production facilities is now underway.

Several plants are operated in conjunction with fertilizer plants, using synthesis gas as feedstock in a bithermal ammonia-hydrogen exchange process. Other inputs obtained from the fertilizer plants are ammonia, steam, and nitrogen. These plants have been particularly affected by problems associated with their dependence upon the fertilizer plants, such as poor or intermittent electricity supply, and interruptions in supply of feedstocks and other necessary inputs. At Baroda and Tuticorin, the synthesis gas has at times also contained less than design levels of deuterium. Since efficient operation of the heavy water plants depends to a great extent on smooth, uninterrupted operation, such problems have caused production to be considerably reduced from rated capacity in some cases. The most serious problems could be greatly helped by the addition of independent, captive electrical power and steam supplies to each plant. In general, the heavy water plants operated in conjunction with fertilizer plants use the

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ammonia-hydrogen exchange process, while others use the hydrogen sulfide-water exchange process.

Existing Heavy Water Plants

1. The Nangal unit, in the state of Punjab, operates in conjunction with a fertilizer plant, using ammonia-hydrogen exchange. It is India's oldest and smallest heavy water plant, first started up over 20 years ago. Capacity is rated at 14 tonnes per year.

2. The plant at Boroda, in Gujarat, has a rated capacity of 67.2 tonnes per year using the ammonia-hydrogen process. Because of frequent interruptions in feedstock and power supplies coming from the fertilizer plant it operates with, maximum production has effectively been only about 45 tonnes per year. Upgrading may allow it to achieve rated capacity in 1987 or 1988.

3. The Kota plant, located at the site of the RAPS reactors in Rajasthan, operates by the bithermal hydrogen sulfide-water exchange process. Water is used as feedstock, and a 5-stage vacuum distillation is used for final enrichment. Design capacity is rated at 100 tonnes per year, but effective capacity has been about 85 tonnes.

4. The plant at Talcher, in Orissa, is dependent upon an ammonia fertilizer plant, and uses the bithermal ammonia-hydrogen exchange process. Synthesis gas is used as feedstock. In April, 1986, a fire caused heavy damage to the Talcher facility. Capacity is rated at 71 tonnes.

5. The Tuticorin plant, in Tamil Nadu, produces heavy water using the ammonia-hydrogen process. Its rated capacity is 71.2 tonnes per year, however effective capacity has been around 50 tonnes. Upgrading is expected to increase production to near design capacity in 1987.

Several other heavy water plants are planned or are under construction. The Thal-Vaishet project, near Bombay, is scheduled for completion in 1987. It uses an ammonia-hydrogen process similar to that used at the Tuticorin facility, and has a rated capacity of 100 tonnes per year. Construction has also started on a new plant at Hazira, in Gujarat, identical in design to Thal-Vaishet. Rated capacity is 100 tonnes, and operation is expected by 1991. A new unit at Maruguru, in Andhra Pradesh, is also under construction, expected to be operational by 1988. It uses the hydrogen sulfide-water process, and has a capacity rated at 185 tonnes.

The five currently operating heavy water plants together have a capacity of between 250 and 325 tonnes D_2O per year. According to Indian sources, meeting the ambitious goals set in the national expansion plan for 10,000 MWe of PHWR capacity will require about 12,000 tonnes per year of heavy water production capability, if self-sufficiency is to be attained. Assuming new heavy water plants begin production exactly as planned, and run at design capacity, by 1992 overall heavy water production capacity will have roughly doubled from the present, to around 600 tonnes per year. During 1985-1986, the heavy water program was allotted nearly 30 percent of the DAE budget.

Conclusion

Prime Minister Rajiv Ghandi has often made reference to India's announced intent to build 10,000 MWe of nuclear capacity by the year 2000. The main thrust of India's commercial nuclear planning is still based on PHWR technology, both because of the experience gained using that reactor type, and because its natural uranium fuel enables India to provide most or all of the fuel requirements, something of great importance in its planning. In addition, fast breeder technology is expected to contribute to nuclear generating capacity sometime in the early 2000s.

India's goal of reaching 10,000 MWe of nuclear generated electrical capacity by the end of the century appears to be quite optimistic. Assuming that all existing reactor capacity is available (1,345 MWe), and that the Narora, Kakrapar, Kaiga, and Rajasthan projects are complete and operating at rated capacity (1,880 MWe) by 2000, the installed nuclear base can be estimated at about 3,200 MWe.

To achieve the additional 6,800 MWe capacity needed to reach the 10,000 MWe goal, several options are available, assuming domestic manufacture and development. Using the 235-MWe PHWR type, for which the design and construction capability is already largely in existence, 15 more twin-unit projects would need to start construction by the early 1990s. An alternative, of unproven merit, would be to introduce the 500-MWe version of the PHWR that has been in design for some time, and which is considered the sucessor to the 235-MWe size. Also, the possibility exists of one fast breeder reactor in operation by 2000, the prototype 500-MWe unit. In any case, reaching the 10,000 target will require more than tripling the existing or firmly planned reactor base.

Although India's present uranium production capability appears adequate to provide fuel supplies for the four operating PHWRs, there is little surplus production available for many new reactors. The feasibility of using thorium as fuel has yet to be demonstrated, and new discoveries of uranium have not proved to be of major significance. It is possible that in the future, if the nuclear expansion program is continued, India could become a buyer on the world uranium market.

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1986 US URANIUM ACTIVITIES

Introduction

Throughout 1986, two main factors affected the US uranium industry; the uncertainties created by the unresolved US producers vs. DOE lawsuit in the Tenth Circuit Court of Appeals, and the low uranium prices on the spot market. However, one encouraging sign was the fact that production rose for the first time in five years. Nuexco estimates 1986 US uranium production from all sources at approximately 13.8 million pounds U_3O_8, a 22-percent rise from the 1985 figure of 11.3 million pounds.

Current production sources include conventional mining and milling, by-product recovery, and solution mining. Six conventional mills were in production at least part-time throughout the year compared to five in 1985. In addition, Homestake Mining Company's mill in Grants, New Mexico operated on a limited schedule, processing small tonnages of ore at various times during the year. Production from conventional sources totaled 8.7 million pounds, almost two-thirds of which came from Chevron and Energy Fuels (and its partners). Table 3 lists the operating status of conventional uranium mills in the USA.

By-product production, including recovery from phosphoric acid and water from underground mines, totaled slightly over 3.6 million pounds, a small increase from the previous year. Uranium was recovered from phosphoric acid at several sites. International Minerals and Chemical Corporation (IMC) continued production at its Plant City and New Wales, Florida operations. No production was reported from IMC's Bartow plant. Freeport Uranium Recovery Company produced from plants located at Donaldsonville and Uncle Sam, Louisiana. The joint venture of Earth Sciences Resources Ltd., and Urangesellschaft mbH (UG) produced uranium from phosphate rock mined in Idaho and processed at an acid plant near Calgary, Alberta, Canada. For the first time in four years there was no production from oxidized copper ores and from leaching copper waste dumps.

Production from solution mining totaled about 1.5 million pounds, of which more than 1.4 million pounds was produced in the South Texas district and the remainder in Nebraska and Wyoming. There was a decrease of 650,000 pounds in uranium from solution mining in 1986, all from the South Texas district.

Project Activity

Surface drilling activity did not change significantly in 1986. Nuexco estimates that a total of 1.9 million feet were drilled, up slightly from 1.8 million feet in 1985. Approximately 70 percent consisted of exploration drilling in search of new deposits; development drilling, used to define the extent and grade of ore deposits, accounted for the remainder. Approximately 60 percent of exploration drilling took place in the South Texas district; the remaining 40 percent was evenly split between northern Arizona and all other areas combined. Approximately 60 percent of development drilling was split between South Texas and Wyoming, primarily the Powder River Basin. Of the remaining 40 percent, about 25 percent was confined to northern Arizona and 15 percent to other districts, notably Nebraska.

Important exploration successes were limited to high-grade mineralization discovered in breccia pipes in northern Arizona, and lower-grade ore zones associated with extensions along known mineral trends, primarily in Tertiary sediments of South Texas, Nebraska and Wyoming. In southeastern Utah, the Salt Wash Member of the Morrison Formation (Jurassic age) and the Shinarump Conglomerate/Monitor Butte channel sequence (Triassic age) have attracted the most interest. The main area of interest in southwestern Colorado (the Uravan Mineral Belt) is the Salt Wash sandstone. In addition to several major mining companies, there are perhaps five or six independent miners now operating in the Utah/Colorado area — another indication that the domestic uranium situation may be improving gradually.

Arizona — The number of companies actively exploring for uranium mineralization associated with solution-collapse breccia pipe structures in the Arizona Strip decreased during 1986. Four major mining companies remain active, but only one or two independent operators are still in the region. Overall, the land position is rather stable — Energy Fuels Nuclear controls about one million acres, Rocky Mountain Energy controls almost 200,000 acres, Pathfinder Mines Corporation controls about 165,000 acres, and perhaps 30,000 to 40,000 acres are under Uranerz Exploration and Mining Limited's control. Energy Fuels is conducting four separate joint ventures for exploration or orebody development throughout the district.

Each company continues to evaluate the potential of new lands, beginning with district reconnaissance. The company identifies a favorable breccia pipe prospect, and attempts to secure an adequate land position. In turn, geophysical and geochemical studies are conducted as a prerequisite to more costly exploration methods. If the study results are positive, exploration drilling is initiated. The discovery of mineralization is followed by detailed development drilling. Complete orebody evaluation is usually accomplished only by sinking a vertical shaft to expose the deposit to geologic study, long-hole drilling, bulk sampling and metallurgical evaluation. Only then can orebody configuration and contained pounds of uranium be determined, and a mine plan and recovery schedule formulated.

Energy Fuels, in conjunction with its partners, continues production from three mines — the Hack 2, Hack 3 and Pigeon. (Stockpiled ore from these mines presently supplies the White

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RAW MATERIALS

Table 3

1986 OPERATING STATUS OF CONVENTIONAL URANIUM MILLS IN THE USA

Company	Approximate Operating Schedule	Rated Capacity[1]	Location
Active Mills			
Chevron Resources Co.	Full	2,500	Hobson, Texas
Cotter Corp.	1/3	1,200	Cañon City, Colorado
Homestake Mining Co.	Partial	3,400	Grants, New Mexico
Pathfinder Mines	1/3	1,800	Shirley Basin, Wyoming
Rio Algom Corp.	Full	750	La Sal, Utah
Umetco/Energy Fuels Nuclear	Full	2,000	Blanding, Utah
Inactive Mills[2]			
American Nuclear Corp.	Inactive	950	Gas Hills, Wyoming
Anaconda (ARCO)	Inactive	6,000	Grants, New Mexico
Atlas Minerals	Inactive	1,400	Moab, Utah
Bear Creek Uranium	Dismantled	2,000	Powder River Basin, Wyoming
Bokum Resources Corp.	Inactive	2,000	Marquez, New Mexico
Conoco/Pioneer	Dismantled	3,400	Falls City, Texas
Dawn Mining Company	Inactive	450	Ford, Washington
Exxon Minerals Company	Dismantled	3,200	Powder River Basin, Wyoming
Quivera Corp. (Kerr-McGee)	Inactive	7,000	Grants, New Mexico
Minerals Exploration Company	Inactive	3,000	Red Desert, Wyoming
Pathfinder Mines	Under Renovation	2,500	Gas Hills, Wyoming
Petrotomics Company	Dismantled	1,500	Shirley Basin, Wyoming
Plateau Resources Ltd.	Inactive	1,000	Ticaboo, Utah
Sohio Western Mining	Dismantled[3]	1,600	Seboyeta, New Mexico
Umetco (Union Carbide)	Inactive	1,300	Uravan, Colorado
Umetco (Union Carbide)	Inactive	1,400	Gas Hills, Wyoming
UNC Resources	Inactive	3,000	Church Rock, Wyoming
Western Nuclear Inc.	Inactive	1,700	Jeffrey City, Wyoming
Western Nuclear Inc.	Inactive	2,000	Wellpinit, Washington

[1]Capacity in tons per day.
[2]Mill inactive throughout 1986.
[3]Began dismantling in September 1986.

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Mesa mill at Blanding, Utah.) The Kanab North deposit is in the late development stage. The shaft was completed to a depth of 1,590 feet, and lateral development into the ore zone from the 1,530 foot level is currently underway . At the Pine Nut deposit, shaft sinking began at the end of 1986. Shaft site preparation is also in progress at the Canyon deposit. In addition, Energy Fuels is currently evaluating additional pipes with identified mineralization. The active mines as well as the Kanab North and Pine Nut deposits are located north of the Colorado River; the Canyon site represents the only development activity south of the river, although several promising structures are being evaluated at this time.

The other three companies are conducting exploration activities throughout their respective land positions, both north and south of the Colorado River. Pathfinder Mines has identified six mineralized pipe structures, five of which are located in the Antelope Valley area of the central Kanab Plateau district, north of the Colorado River. Two pipes have been defined by surface drilling, but additional drilling is needed on the other four pipes, including the site located south of the river. Rocky Mountain Energy and Uranerz have not announced exploration results to date, although both have been active in the district for several years.

Texas — Production by solution mining methods totaled almost 1.5 million pounds U_3O_8, the lowest amount in the last five years. Six companies reported production, but only Everest Minerals Corporation and the US Steel/NM Uranium joint venture operated at close to a full schedule, together accounting for over one million pounds of the total. The other four companies, in the midst of partial or full restoration programs, produced small quantities. Solution mining projects and the status of each are listed in Table 4.

Conventional production in Texas was limited to the Panna Maria mill at Hobson. Chevron Minerals Corporation, operator of the mill, produced over one million pounds U_3O_8 by processing ore transported from its Mt. Taylor mine, located in the Ambrosia Lake district of New Mexico. No ore was produced by conventional mining in Texas during 1986.

Five companies conducted exploration drilling, the same number as in 1985. As in previous years, the primary target was new ore deposits in the Goliad Formation (Pliocene age), which may have the greatest potential for larger and higher-grade deposits, as well as favorable leaching characteristics. The main exploration effort continued along trend extensions through Brooks, Duval, Jim Wells, and Kleberg counties. Exploration for new desposits in the Oakville and Catahoula formations (Miocene age) occurred in Live Oak and Bee counties as well. The rate of success is unknown, as no discoveries were announced.

Table 4

SOLUTION MINING PROJECTS IN THE USA

Project	Status
Chevron Minerals Corporation	Palagana project in full restoration.
Everest Minerals Corporation	Mt. Lucas project in full production; Tex-1 pilot project on standby; Los Palmas in final restoration.
Intercontinental Energy Corporation	Zamzow project in final restoration phase; Lamprecht project entering new production/restoration phase.
Mobil Alternative Energy, Incorporated	Holiday-El Mesquite-O'Hern project in production/restoration phase.
Uranium Resources Incorporated (URI)	Bruni and Benavides projects in final restoration phase.
US Steel Corporation	Burns project in full restoration; US Steel/Niagara Mohawk Uranium, Clay West project in production/restoration phase.

Wyoming — Only one conventional project operated throughout the year. Production from Pathfinder's Shirley Basin open-pit mine and acid leach mill totaled about one-third nominal capacity. The company currently is stripping the overburden from the adjacent property acquired from Petrotomics in 1985. That ore zone is an extension from Pathfinder's No. 2 Pit, which is essentially mined out. Eventually, waste material from the new pit will be used for backfilling in the No. 2 Pit. The new ore source is expected to add several years to the life of the Shirley Basin operation.

Interest in solution mining is limited to the South Powder River Basin, where the only sustained production comes from the Bill Smith project operated by Sequoyah Fuels Corporation (a subsidiary of Kerr-McGee Corporation). Everest Minerals Corporation continues to evaluate its Highland property (acquired from Exxon in 1984) as it awaits finalization of the permitting and licensing process. Plant construction is scheduled to begin in 1987, followed by production in 1988. In August, Malapai Resources initiated a solution mining pilot test on the Willow Creek deposit located on the Christensen Ranch property. Permits for the project allowed testing of sodium and

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bicarbonate lixiviants at separate sites. The sodium test was completed by the end of the year, and startup of the restoration phase is contingent upon agency approval. The bicarbonate test will begin in early 1987.

In general, exploration activity was confined to annual assessment requirements associated with mining claims scattered throughout each Tertiary basin in the state. A number of companies and individuals continue to maintain their property positions in anticipation of a resurgence in the uranium industry. Other specific areas of exploration and development drilling activity included Green Mountain, located south of Jeffrey City in Fremont County; Shirley Basin; the Gas Hills; and the South Powder River Basin in Converse County. Everest Minerals completed over 200,000 feet of drilling on the Highland site in preparation for solution mining.

Nebraska — Exploration and development consisted of Ferret Exploration Company's activities in Dawes and Box Butte counties. Ferret initiated a solution mine pilot test on the Crow Butte deposit in August, operating at a rate of 100 gallons per minute. Two wellfield patterns are involved, one of which is scheduled to demonstrate restoration procedures in early 1987. The other wellfield may be the basis for later expansion to commercial production. The success of the pilot operation to date indicates the ore deposit is amenable to solution mining techniques. As sole owner of the project, Ferret is structuring a joint venture whereby it will remain as project operator. Joint venture negotiations were in progress as of the end of the year.

Ferret continued to evaluate the Big Red claim group, which covers the trend extension of the Crow Butte deposit. Exploration and fill-in drilling completed in 1986 produced favorable results. The company is optimistic about project potential at this time, and has scheduled additional drilling in 1987.

Utah — Two conventional processing mills operated full time throughout 1986. Rio Algom Corporation's mine and mill at La Sal processed ore from its Lisbon mine, supplemented by ore purchased from a few independent mine operators. Rio Algom is scheduled to continue operation through 1987. The Umetco/Energy Fuels mill at White Mesa also operated for the entire year, fed with ore from mines in the Arizona Strip owned by Energy Fuels and its Swiss partners. Umetco processed no ore through the mill in 1986. In addition, the mill processed ore from independent miners. The mill is scheduled to continue operations through the first four to six months of 1987.

Exploration activity occurred on a limited basis, primarily as required to maintain mining lode claims. Areas of interest included the Lisbon Valley, White Canyon, Cottonwood Wash and Elk Ridge areas. Overall, exploration efforts were directed at possible trend extensions of the large high-grade ore deposits which were mined during the past 30 years. The target of exploration in the Lisbon Valley is new ore deposits in the Mossback Member of the Chinle formation (Triassic age), and the underlying Cutler Formation (Permian age); in White Canyon and Elk Ridge, companies are focusing on ore in the Shinarump Conglomerate (Triassic age); in Cottonwood Wash the target is ore in the Salt Wash Member of the Morrison Formation (Jurassic age).

Colorado — Cotter Corporation operated the Cañon City mill at about one-third capacity throughout the year, using ore from the Schwartzwalder mine located near Golden. The ore is trucked to the mill site where it is stockpiled for later milling. Production at the Schwartzwalder mine has been maintained at about 400 short tons per day. However, Cotter announced in January 1987 that uranium production operations had been suspended pending an improvement in the uranium market.

Exploration and development focused primarily on the south end of the Uravan Mineral Belt in southwestern Colorado, and is an extension of the activity in Utah. In the same vicinity, Umetco, Cotter, and others completed annual claim requirements and maintained some mines on a standby basis. Mine production reached an all-time low, as only one independent miner produced from a deposit in the Salt Wash formation, located on the Utah/Colorado border.

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Table 5

1986 Uranium-Related Activities in the USA

Month	Organization	Event or Announcement
January	Sequoyah Fuels	Accident at the conversion facility disrupted slurry deliveries from small solution miners. Some projects were forced to curtail operations.
January	Phillips Minerals	Announced it will abandon the Nose Rock mine project, Grants Mineral Belt, New Mexico.
March	Chevron Corporation	Announced mining would continue at Mt. Taylor, Ambrosia Lake district, New Mexico.
March	State of New Mexico	Requested that NRC assume regulatory responsibility for uranium mill tailing sites.
April	Uranium Resources, Inc.	Requested permit to solution mine Kingsville Dome deposit, Kleberg County, Texas.
April	Philadelphia. Electric Company	Transferred its 50-percent interest in the Lee mine, Ambrosia Lake district, New Mexico, to Quivira Mining Co., the original owner.
April	Public Service Electric & Gas Company	Terminated 1976 uranium supply contract with Homestake Mining Co.
April	Senator Domenici (R, New Mexico)	Introduced amendment to the Uranium Mill Tailings Reclamation Act of 1985, proposing to reduce uranium imports to 50 percent, establish plan to pay for cleanup of mill tailings, and reorganize the DOE uranium enrichment program. (The bill was not passed in that session of Congress, but could be reintroduced during 1987.)
May	Nuclear Regulatory Commission	Allowed Sequoyah Fuels to start receiving shipments of yellowcake. Small miners began to make slurry shipments.
May	Chevron Resources	Secured a one-year option to purchase the Rhode Ranch deposit, South Texas district.
May	UG USA Inc.	Announced intent to produce byproduct uranium in 1987 at the Bartow, Florida phosphate plant (the uranium plant was purchased from Westinghouse in 1986).
May	Ferret Exploration Company	Purchased Wyoming Fuel Company's 50-percent interest in the Crow Butte project, northwestern Nebraska.
June	US District Court	Ordered DOE to limit amount of foreign uranium it enriched for US utilities to 25 percent of total through 1986, and none thereafter.
June	Nuclear Regulatory Commission	Agreed to assume regulatory authority over New Mexico uranium milling operations.
July	US Department of Energy	Was granted a stay pending appeal of Judge Carrigan's order.
July	Rocky Mountain Energy	Announced signing of a five-year joint venture agreement with Taiwan Power Company for uranium exploration in the USA.
September	Sohio Western Mining	Initiated plan to decommission L-Bar mine and mill, Seboyeta, New Mexico.
September	Uranium Resources, Inc.	Submitted plan to Texas regulatory agencies for solution mining the Rosita deposit, South Texas district.
September	ARCO, et al	Relinquished to US Energy Corp. their mining lease on the APT deposit, Green Mountain district, Wyoming.
October	US Congress	Banned import of uranium ore and concentrates from South Africa.

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Table 5

1986 Uranium-Related Activities in the USA

Month	Organization	Event or Announcement
October	American Nuclear	Sought NRC and Wyoming state approval to move 1.5 million yards of mill tailings from abandoned Riverton, Wyoming site to ANC tailings site in Gas Hills, Wyoming.
October	Altair Resources	Began ground water treatment at the Bison Basin site, Red Desert, Wyoming under contact to the Wyoming Department of Environmental Quality.
October	Sequoyah Fuels	Conversion facility allowed to resume operations, after being closed since January accident.
November	Uranium Resources, Inc.	Received approval from Texas Water Commission to solution mine the Kingsville Dome deposit.
November	Union Carbide Corporation	Agreed to pay $42 million in reclamation costs at its Uravan, Colorado mill site.
November	Homestake Mining Company	Announced plan to reduce mining rate, Ambrosia Lake, New Mexico to 50 t/d from current rate of about 130 t/d.
December	Energy Fuels Nuclear	Began negotiating to purchase Quivira Mining Corporation, Ambrosia Lake, New Mexico.
December	US Department of Energy	Energy Secretary John Herrington declared US uranium industry nonviable in 1985, for the second consecutive year.

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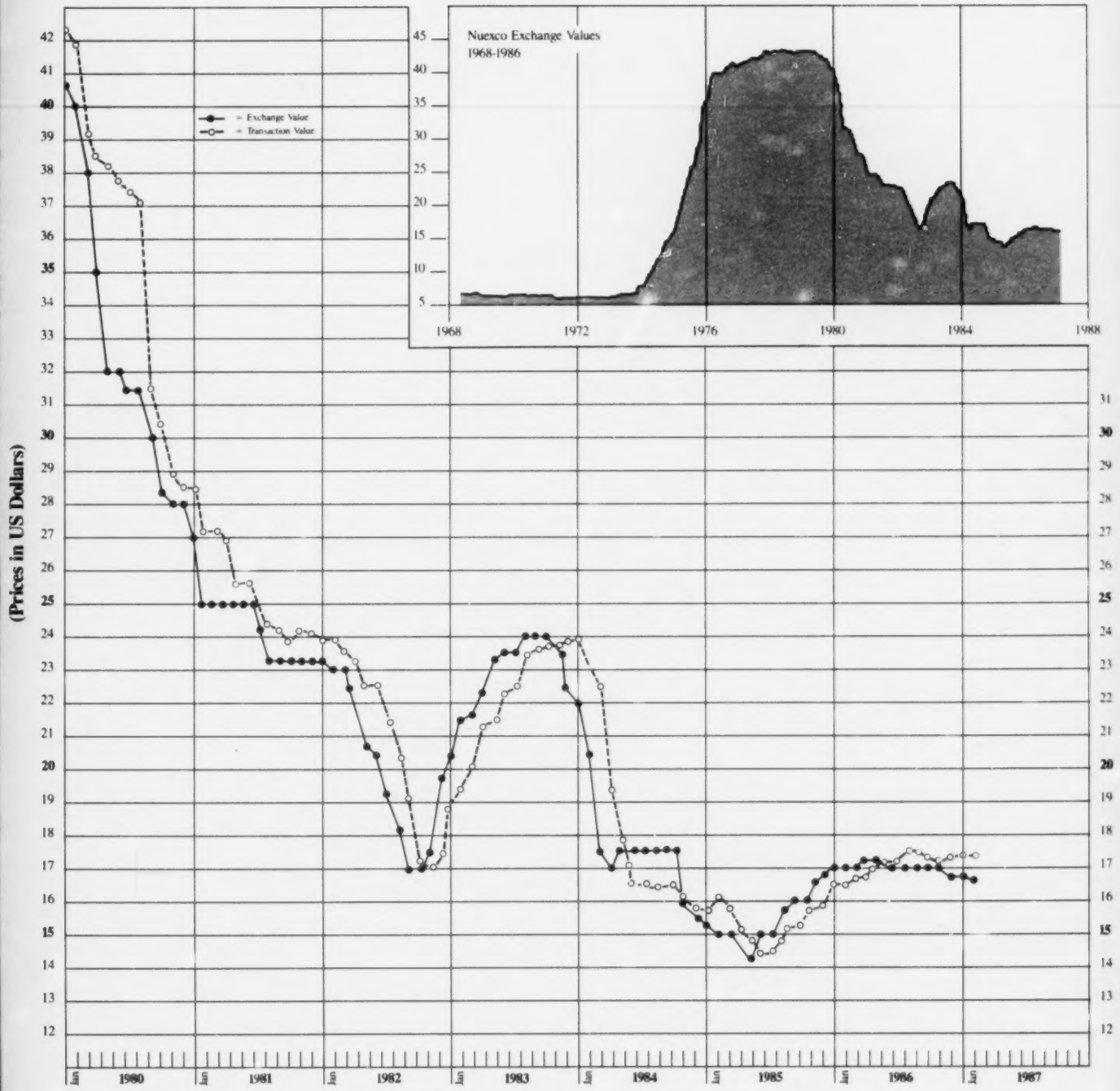
HISTORICAL MARKET DATA



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HISTORICAL MARKET DATA

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	**16.65**											

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.15	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	**17.35**											

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HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.80	1.90	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	**1.80**											

HISTORICAL UF_6 VALUES

Determined as of the last day of the month indicated (US Dollars/kg. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	**47.75**											

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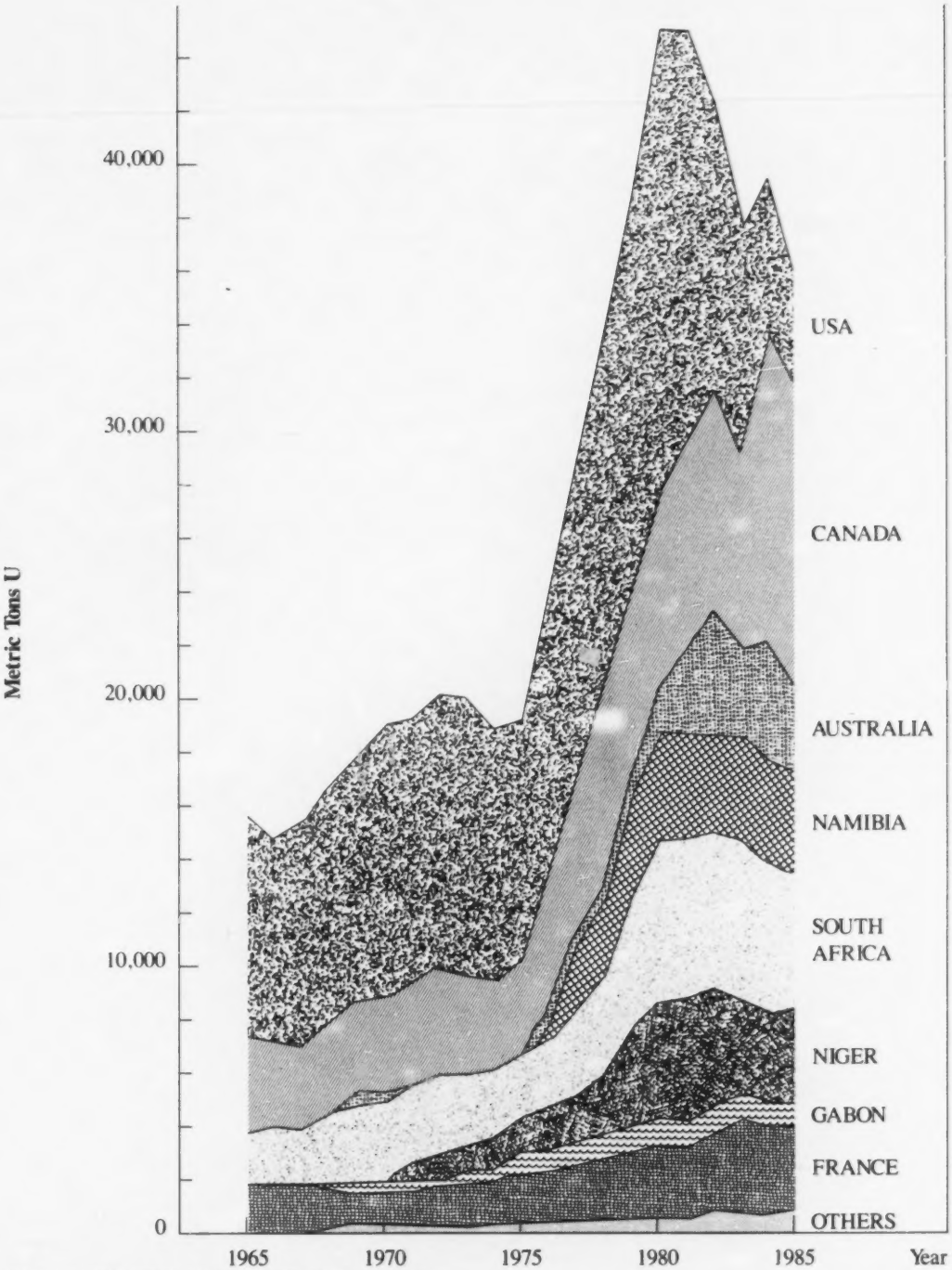
HISTORICAL MARKET DATA

HISTORICAL WOCA[1] URANIUM PRODUCTION[2]
(Compiled by OECD/IAEA Joint Report[3])



[1]WOCA = World Outside of Centrally-planned Economic Areas.
[2]1985 production data are preliminary.
[3]A joint report issued biennially by the OECD Nuclear Energy Agency and the International Atomic Energy Agency.

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US URANIUM MARKETING ACTIVITIES STATISTICS[1]
(Compiled from data published by the US Energy Information Administration)

Year	Total Production[2] (million pounds U_3O_8)	Deliveries to Domestic Utilities[3] (million pounds U_3O_8)	Average Price of Delivered Uranium ($/lb. U_3O_8)	Quantity of Uranium Imported[4] (million pounds U_3O_8)	Average Price of Imported Uranium ($/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	n/a	n/a	3.6	n/a	1.2
1977	29.9	n/a	n/a	5.6	n/a	4.0
1978	37.0	n/a	n/a	5.2	n/a	6.8
1979	37.5	33.0[5]	$23.85[5]	3.0	n/a	6.2
1980	43.7	35.0[5]	$28.15[5]	3.6	$43.10	5.8
1981	38.5	32.6[5]	$34.65[5]	6.6	$32.90	4.4
1982	26.9	27.1	$38.37	17.1	$27.23[6]	6.2
1983	21.2	24.2	$38.21	8.2	$26.16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3

[1]Sources: 1979: US Department of Energy, Assistant Secretary for Resource Applications, Office of Uranium Resources and Enrichment, *Survey of United States Uranium Marketing Activity*, DOE/RA-0053 (Washington DC, July 1980). 1980-1981: US Department of Energy, Assistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment, *Survey of United States Uranium Marketing Activity*, DOE/NE-0013 and DOE/NE-0013/1 (Washington DC, June 1981 and July 1982). 1982: Energy Information Administration, *1982 Survey of United States Uranium Marketing Activity*, DOE/EIA-0403 (Washington DC, September 1983). 1983: Energy Information Administration, *Survey of United States Uranium Marketing Activity 1983*, DOE/EIA-0403(83) (Washington DC, August 1984). 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[2]Sources: 1976-1982: US Department of Energy, Grand Junction Area Office, *Statistical Data of the Uranium Industry*, GJO-100 (Grand Junction, Colorado, January 1983). 1983: Calculated by the staff of the Nuclear and Alternate Fuels Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, from US Department of Energy, Grand Junction Area Office data files. 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[3]Excludes direct imports by domestic utilities.

[4]Includes imports by domestic utilities and domestic suppliers.

[5]Includes delivery commitments to domestic utilities and agents.

[6]Computation of quantity-weighted average price excludes the quantity associated with a large exchange (swap) transaction that occurred in 1982.

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HISTORICAL MARKET DATA

VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]
(Compiled from data published by the Euratom Supply Agency)

Year	Volume of Deliveries to the EC[2] (in MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3,4]		Spot Contracts[3,4]	
			Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8	Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00

[1]The twelve European Community member nations are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EC.

[2]The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3]For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar.

[4]Exchange rates as published by European Communities Statistical Office and the International Monetary Fund.

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AUSTRALIA

	Price Index of Materials Used in Manufacturing Industry — All Groups[1] (1984 = 100)	Award Rates of Pay Indexes Australia — Adult Males In Mining Wage Earners, Weekly Rates[2] (1976 = 100)
1975 Avg.	150.4	132.6
1976 Avg.	168.4	160.9
1977 Avg.	192.0	179.0
1978 Avg.[3 4]	198.5	190.0
1979 Avg.	248.8	127.9
1980 Avg.	321.8	140.8
1981 Avg.	355.3	154.1
1982 Avg.[5]	368.6	174.9
1983 Avg.	401.6	181.8
FY84 Avg.[6]	95.3	—
FY85 Avg.[6]	100.0	—
Jan 1985	97.0	197.8
Feb 1985	98.6	197.8
Mar 1985	102.1	197.8
Apr 1985	104.4	202.8
May 1985	107.6	202.4
Jun 1985	108.7	202.4
Jul 1985	111.1	202.4
Aug 1985	110.5	202.4
Sep 1985	108.7	202.5
Oct 1985	108.4	202.4
Nov 1985	109.4	209.9
Dec 1985	110.0	210.0
Jan 1986	109.6	210.0
Feb 1986	108.7	210.0
Mar 1986	99.5	210.5
Apr 1986	94.3	210.5
May 1986	93.5	210.5
Jun 1986	95.7	210.5
Jul 1986	98.1	215.2
Aug 1986	98.2	215.2
Sep 1986	105.6	215.3
Oct 1986	106.1	215.4
Nov 1986	—	215.6

P = Preliminary R = Revised since last month

[1]Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0). The basis of this index was revised to 1984 = 100. The previous index was 1969 = 100.

[2]Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.

[3]Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.

[4]Annual averages prior to 1979 reflect index base no longer in use.

[5]Monthly data for 1979-82 appear on page 35 of Report 184.

[6]Annual averages are for financial year ending June 30.

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GOVERNMENT STATISTICS

CANADA

	Industry Selling Price Index: All Commodities[1] (1981 = 100)	Wage-earner Data: Average Hourly Earnings (C$)[2]					
		Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Primary Non-ferrous Metal Industries[4] (SIC 296)	(SIC 298)	Chemicals and Chemical Products[5] (SIC 372-379)
1979 Avg.[6]	217.9	—	9.60	9.66	—	—	7.67
1980 Avg.	247.2	—	10.58	10.80	—	—	8.50
1981 Avg.	288.7	—	12.02	12.23	—	—	9.53
1982 Avg.[7]	288.8	—	13.74	13.92	—	—	10.63
1983 Avg.	298.8	—	—	14.30	—	—	11.17
1984 Avg.	310.9	17.88	—	15.07	12.28	10.49	11.76
Jan 1985	117.5	18.05	16.13	15.60	12.32	10.80	12.04
Feb 1985	117.7	18.78	16.41	15.68	12.52	11.05	12.06
Mar 1985	118.4	18.24	16.21	15.57	12.44	10.97	12.02
Apr 1985	118.3	18.63	16.44	15.80	12.81	11.23	12.04
May 1985	118.6	19.41	16.51	15.63	12.76	11.25	12.15
Jun 1985	118.6	18.49	16.20	15.49	12.89	11.14	12.14
Jul 1985	118.6	18.14	16.27	15.41	12.96	11.17	12.13
Aug 1985	118.4	17.07	16.03	15.30	12.97	11.31	12.19
Sep 1985	118.6	18.53	16.55	15.72	12.95	11.39	12.26
Oct 1985	119.0	18.74	16.51	15.70	13.14	11.53	12.33
Nov 1985	119.3	19.05	16.66	15.88	12.76	11.32	12.49
Dec 1985	120.0	19.07	16.57	16.01	12.51	11.09	12.59
Jan 1986	121.0	18.15	16.22	15.86	13.11	11.48	12.52
Feb 1986	120.8	19.52	16.57	15.99	13.20	11.59	12.45
Mar 1986	120.1	19.04	16.65	15.93	13.11	11.59	12.54
Apr 1986	119.3	19.38	16.68	15.95	13.07	11.64	12.54
May 1986	118.4	19.54	16.68	15.78	13.16	11.72	12.51
Jun 1986	118.6	19.80	16.63	15.64	13.44	11.86	12.49
Jul 1986	118.8R	19.51	16.34	15.48	13.28	11.73	12.52
Aug 1986	119.1	18.39	16.17	15.46	13.31	11.31	12.70
Sep 1986	119.3R	19.32	16.62R	15.78R	13.14R	11.45R	12.90R
Oct 1986	119.8	19.97P	16.80P	15.92P	13.21P	11.49P	12.89P
Nov 1986	119.8P	—	—	—	—	—	—

P = Preliminary R = Revised since last month

[1]Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Index prior to 1985, 1971 = 100.

[2]Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (Catalogue 72-002).

[3]Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

[4]Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5]Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6]Monthly ISPI for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

[7]Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled "Metal Mining, Including Milling (SIC 050-099)" should read "Total Mining (SIC 051-099)."

[8]Beginning with the March 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, *plus* a random survey of companies employing fewer than 200 wage earners. Prior to March 1983 only companies employing 200 or more wage earners are included in the Wage Earner Data.

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REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1980 = 100)[4]	Producer Price Index All Groups[5] (1980 = 100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1975	Avg.	16.71	—	157.2	100.0	639,473	1,003,617
1976	Avg.	19.30	—	174.7	115.1	671,240	1,212,983
1977	Avg.	23.87	—	194.4	130.0	712,006	1,420,670
1978	Avg.	27.14	—	137.2	142.7	664,571	1,537,169
1979	Avg.[7]	30.18	—	155.3	164.5	692,209	1,830,632
1980	Avg.[8]	35.53	—	176.7	192.1	714,379	2,279,615
1981	Avg.	41.89	—	206.5	218.3	728,506	2,820,505
1982	Avg.[9]	47.25	104.2	233.5	248.7	707,552	3,246,071
1983	Avg.	51.87	115.0	262.2	274.8	696,579	3,644,772
1984	Avg.	58.95	130.3	292.8	297.9	712,080	4,196,764
Jan	1985	—	—	177.1	166.6	711,366	376,777
Feb	1985	—	—	182.8	171.3	727,932	361,823
Mar	1985	64.48	142.4	183.6	173.0	708,809	371,380
Apr	1985	—	—	187.4	174.0	724,187	369,005
May	1985	—	—	189.5	177.7	708,085	373,478
Jun	1985	67.42	148.9	191.9	179.2	724,587	395,543
Jul	1985	—	—	193.6	180.7	738,228	419,106
Aug	1985	—	—	195.6	183.2	734,121	416,777
Sep	1985	70.47	155.3	197.8	184.8	732,836	419,883
Oct	1985	—	—	200.8	188.1	720,071	401,448
Nov	1985	—	—	203.4	196.0	750,049	432,996
Dec	1985	72.43	160.1	207.4	199.4	741,372	425,261
Jan	1986	—	—	213.8	203.6	744,070	449,513
Feb	1986	—	—	215.8	206.9	754,458	438,562
Mar	1986	75.76	167.8	218.3	206.9	759,897	445,387
Apr	1986	—	—	222.2	208.9	756,388	437,563
May	1986	—	—	222.6	212.5	754,788	425,544
Jun	1986	77.65	172.0	224.4	213.3	756,637	462,365
Jul	1986	—	—	228.8	216.3	756,140R	516,832
Aug	1986	—	—	232.2	220.3	760,925	502,968
Sep	1986	81.94	181.8	236.7	221.9	764,562	510,665
Oct	1986	—	—	239.3	226.8	—	—
Nov	1986	—	—	242.4	230.2	—	—
Dec	1986	85.38	189.9	244.9	—	—	—

P = Preliminary R = Revised since last month

[1]Chamber of Mines of South Africa, Johannesburg; "Analysis of Working Results," published quarterly.

[2]Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3]Republic of South Africa Department of Statistics, Pretoria; "Government Gazette: Consumer Price Index for Urban Areas."

[4]The basis for calculation prior to January 1985, 1975 = 100. For annual averages prior to 1978, April 1970 = 100.

[5]Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same. The basis for calculation prior to January 1985, 1975 = 100.

[6]Bulletin of Statistics, Department of Statistics, Pretoria.

[7]Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.

[8]Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157.

[9]Monthly data for 1979-82 appear on page 39 of Report 184.

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GOVERNMENT STATISTICS

UNITED STATES

	Producer Price Index[1]		Consumer Price Index[2]	GNP Implicit Price Deflator[3,4]	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[5]			
	Industrial Commodities (1967 = 100)	All Commodities (1967 = 100)	(1967 = 100)	(1982 = 100)	Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980 Avg.[6]	274.8	268.8	246.8	178.64	10.26	10.63	8.30	6.94
1981 Avg.	304.1	293.4	272.4	195.51	11.55	11.98	9.12	7.62
1982 Avg.[7]	312.3	299.3	289.1	207.15	12.33	12.94	9.96	8.21
1983 Avg.	315.8	303.1	298.4	215.63	12.57	13.43	10.59	8.65
1984 Avg.	322.6	310.3	311.1	108.1	13.05	13.43	11.08	9.04
Jan 1985	322.9	309.5	316.1	—	13.29	13.70	11.39	9.33
Feb 1985	322.5	309.2	317.4	—	13.30	13.73	11.39	9.33
Mar 1985	322.6	308.7	318.8	110.4	13.29	13.95	11.37	9.39
Apr 1985	323.8	309.3	320.1	—	13.43	13.63	11.47	9.40
May 1985	325.3	309.8	321.3	—	13.24	13.60	11.44	9.39
Jun 1985	324.8	309.2	322.3	111.3	13.23	13.68	11.51	9.46
Jul 1985	324.4	309.0	322.8	—	13.45	13.83	11.59	9.47
Aug 1985	323.7	307.3	323.5	—	13.55	13.71	11.60	9.50
Sep 1985	322.3	305.5	324.5	112.1	13.44	13.68	11.65	9.54
Oct 1985	324.2	307.9	325.5	—	13.49	13.66	11.70	9.55
Nov 1985	324.7	309.5	326.6	—	13.49	13.97	11.80	9.61
Dec 1985	325.1	310.2	327.4	113.0	13.43	13.81	11.85	9.68
Jan 1986	323.8	308.9	328.4	—	13.40	13.69	11.86	9.60
Feb 1986	318.9	304.4	327.5	—	13.44	13.82	11.81	9.60
Mar 1986	314.0	300.3	326.0	113.5	13.38	13.93	11.78	9.62
Apr 1986	311.6	298.2	325.3	—	13.54	13.87	11.82	9.62
May 1986	311.6	299.2	326.3	—	13.46	13.79	11.89	9.64
Jun 1986	311.8	299.0	327.9	114.2	13.52	13.49	11.94	9.61
Jul 1986	308.5	297.4	328.0	—	13.47	13.22	12.04	9.68
Aug 1986	307.9R	297.2	328.6	—	13.04	13.18	11.99	9.67
Sep 1986	308.8	297.7	330.2	115.0	13.11	13.41	12.03	9.73
Oct 1986	309.3	298.3	330.5	—	12.91R	13.29R	12.08	9.72R
Nov 1986	309.8	298.7	330.8	—	12.78P	13.31P	12.14R	9.74R
Dec 1986	309.3	298.1	331.1	115.3	—	—	12.19P	9.87P

P = Preliminary R = Revised since last month

[1]US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2]US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3]US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4]The basis for calculation of this index was revised to 1982 = 100. 1984 and 1985 figures have been adjusted to that basis. The basis for calculation prior to 1984, 1972 = 100.

[5]US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 and beyond are adjusted to the March 1980 benchmark.

[6]Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28, and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139.
Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147.
Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154.
Monthly data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[7]Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

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